QUEENSLAND EMERGENCY
RISK MANAGEMENT FRAMEWORK (QERMF)

RISK ASSESSMENT PROCESS HANDBOOK

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Queensland Government

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Overview

Aim of the handbook

This handbook provides a valuable risk assessment methodology that can be used within disaster management planning at all levels of Queensland's Disaster Management Arrangements (QDMA) – Local, District and State. The process applies a proven, standardised and internationally recognised approach to the prioritisation, mitigation and management of risk. This includes identification of capacity gaps and residual risk between stakeholders and the QDMA. This assists to directly inform planning and resource allocation, and to promote active communication, cooperation and coordination.

This handbook outlines both the framework and approach for this risk assessment process in a step-by-step manner and provides examples, resources and templates to assist in its implementation.

Benefits of this risk assessment process

In short, this process ensures four key outcomes:

- shifts risk assessment and management from a 'one size fits all' approach to a tailored methodology that accounts for the prioritisation of local characteristics
- embeds risk identification, assessment and management in proven, consistent, science-based methodologies that can be applied consistently across all levels of QDMA (Local, District and State)
- allows clarity and transparency in communication and decision-making at all levels of QDMA
- improves the identification of an area's capability and capacity to manage the risks within that area, thereby informing resource planning for QDMA.

This in turn will create multiple benefits, including:

- risk governance will be improved through the strengthening of transparency and accountability in the acceptance, mitigation and/or transfer of residual risk between and across the three levels of QDMA
- specific areas can prioritise their resources, based on localised assessed risks
- robust, scientifically-based risk assessments can be used for applications for resources and funding towards mitigation strategies and betterment projects
- all levels of government and community will have greater assurance through and confidence in scientifically underpinned risk based planning
- stakeholders will have improved confidence in State level coordination and support across all levels of QDMA, supported by State Government guidance and prioritisation of hazard risk
- disaster management networks will be strengthened and better aligned.

The QERMF is underpinned by a multidisciplinary approach, uniting international and Australian best practice, the strategic direction of world risk management leaders and using operational geospatial intelligence to undertake exposure and vulnerability analysis which can directly inform the State's multitiered disaster management arrangements and planning.

The QERMF derives risk methodology from:

- ISO 31000:2009 Risk management – Principles and guidelines
- SA/SNZ HB 436: 2013 Risk management guidelines – companion to AS/NZS ISO 31000:2009
- SA/SNZ HB 89:2013 Risk management – Guidelines on risk assessment techniques
- AS/NZS 5050: 2010 Business continuity – Managing disruption related risk
- National Emergency Risk Assessment Guidelines (NERAG) (Australian Emergency Management Institute, 2015).

In addition to the above international and national standards, the QERMF also upholds international best practice as championed by the United Nations Office for Disaster Risk Reduction (UNISDR) and the Global Facility for Disaster Reduction and Recovery (GFDRR) and seeks to literally enact the Sendai Framework for Disaster Risk Reduction's (Sendai Framework) "Priorities for Action".

The Queensland Emergency Risk Management Framework's approach to managing risk

> *The concept of risk combines an understanding of the probability of a hazardous event occurring with an assessment of its impact represented by interactions between hazards, elements at risk and vulnerability.*
>
> *(Geoscience Australia)*

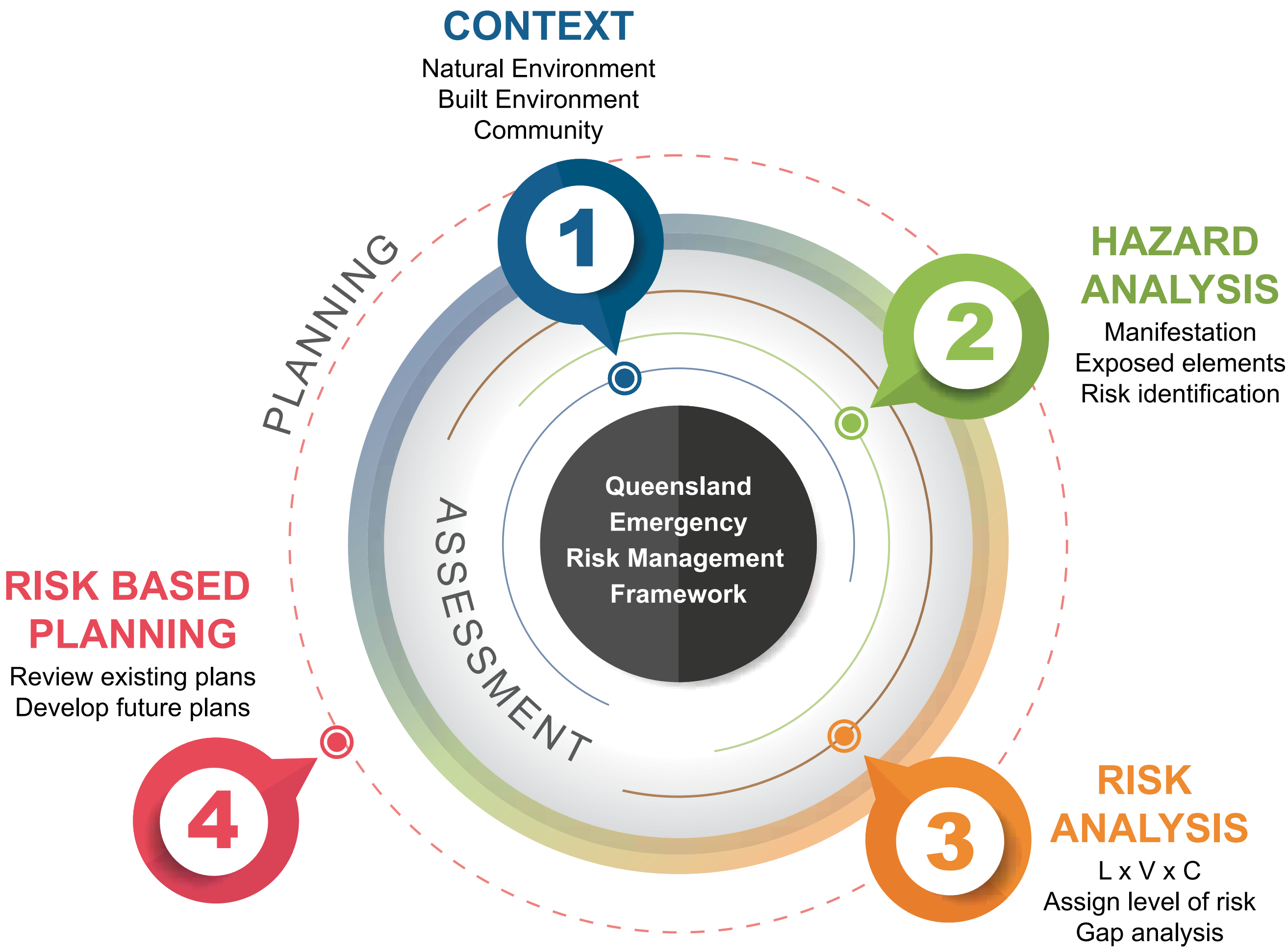


Figure 1 - Queensland Emergency Risk Management Framework

The successful foundation for disaster risk management lies in clearly identifying and understanding the level of exposure and vulnerability to a community and its assets against particular hazards.

Effective risk assessments produce information that is targeted, authoritative, understandable and usable. The model above depicts the overarching risk based planning methodology within the QERMF. This model shows the four clear steps to ensuring the identification, analysis and management of risk, summarised overleaf.

[1] Global Facility for Disaster Reduction and Recovery (2014) – *Emerging Best Practices in Natural Disaster Risk Assessment. World Bank*

Step one: Establishing the context

The processes shown within the first step of the QERMF establish the context of the area under assessment. This includes understanding the natural landscape through the study of the environment and/or by accessing basic geomorphology information. Much of this information is available through local governments as well as the Queensland Government.

Typically, this assessment begins with an appreciation of the ‘lay of the land’ via geospatial data/layers, which highlight the specific characteristics of the natural environment.

Next, this information is integrated with the specific characteristics of the area’s community (its demography) and built environment (its infrastructure, road networks, buildings), as well as any socially or culturally valued areas or sites (such as sacred sites, environmentally sensitive areas, tourist spots, churches and community centres or key landmarks).

It is particularly important to identify critical and significant infrastructure (such as power, water, communications) as well as the associated networks and dependencies/interdependencies they need to effectively operate (and be accessible) as damage or disruption to these elements requires immediate response and can launch a cascade of associated vulnerabilities.

The majority of this information can be displayed in geospatial layers and is a precursor to commencing the actual risk assessment process. Geospatial layers can create an accurate visualisation of how the hazard will manifest on the local natural and built environment, which in turn informs our assessment of the vulnerabilities we have and our capability and capacity to manage those vulnerabilities.

Step two: Analysing hazards

The second step focuses on hazards and how they will behave when they actually occur. Identifying relevant hazards and collecting hazard-related data is essential when quantifying risk. Relevant hazards are identified through probabilistic analysis of historical data for a specific area or region.

Once the hazards are defined, the next step involves acquiring a variety of hazard related data. Hazard specific data, layers, mapping and modelling is available through Geoscience Australia, the Bureau of Meteorology and the Department of Science, Information Technology and Innovation, as well as other agencies and local governments.

The most fundamental data define historical events including their date, geographical location and extent, and maximum intensity. However, this information is only the beginning, as we will discuss further in this handbook.

Step three: Assessing risk

The third step formalises the risk analysis process and leads directly to the clear identification of risk that may arise when a potential hazard becomes reality. This process also includes reviewing existing controls to manage or mitigate risks and identifying any capability or capacity gaps in meeting the required response. This in turn highlights what is known as the residual risk – the risk that remains in unmanaged form even when effective disaster risk reduction measures are in place. This approach also provides the means to consistently record the identification and management of risk, using essential documents such as working tables, registers and a decision log.

The literal nature of the entire process enables the geospatial information and the tables and registers to be used jointly in situational briefings when required.

Step four: Risk based planning

Lastly, the fourth step involves risk based planning. This comprises the treatment of identified risk and the management of residual risk, and allows for effective planning at and between all levels of QDMA – Local, District and State. Mitigation strategies and risk treatment options may be short or long term focussed. In some instances, an interim strategy may be required if a mitigation treatment is complex and will take some time to implement. Indeed, if a mitigation strategy entails a project not expected to be completed in the short term then contingency/response plans are expected to be identified to cover the gap.

QERMF's approach to risk based planning, and the philosophy underpinning the risk assessment process in this handbook, can best be summarised by the following statement:

The Global Facility for Disaster Reduction and Recovery (2014) note: *"Risk information must be scientifically and technically rigorous, open for review, and honest regarding its limitations and uncertainties, which may arise from uncertainties in the exposure data, in knowledge of the hazard, and in knowledge of community vulnerability. The best way to demonstrate credibility is to have transparent data, models, and results open for review by independent, technically competent individuals."*

Hazards

Hazards may be natural, anthropogenic or socionatural in origin. **Natural hazards** are predominantly associated with natural processes and phenomena. **Anthropogenic hazards**, or human-induced hazards, are induced entirely or predominantly by human activities and choices. This term does not include the occurrence or risk of armed conflicts and other situations of social instability or tension which are subject to international humanitarian law and national legislation. **Socionatural hazards** are associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change.

Hazards may be single, sequential or combined in their origin and effects. Each hazard is characterised by its location, intensity or magnitude, frequency and probability.[2]

The QERMF can accommodate all hazards as per the Disaster Management Act 2003.[3] However, not all natural and anthropogenic hazards are applicable to all areas of Queensland. The selection of applicable hazards is based on what is pertinent (i.e. historically, geographically and so on) to the area under assessment.

When analysing the potential impacts of the manifestation of a hazard – and understanding their characteristics in detail – it is evident that secondary hazards may occur from a primary event. For example, a tropical cyclone can lead to flash flooding and storm surges; riverine flooding can bring erosion and landslides. Therefore the interaction of the primary and secondary hazards and their cascading effects need to be considered. Primary and secondary hazard characteristics listed in Figure 2 are by no means exhaustive and professional judgement, consultation and historical analysis should be applied at all times.

Assessing the hazard interaction and the impact of the characteristics of those hazards upon exposed elements provides a clear understanding of the vulnerabilities of the area under assessment.

Hazard – a source of potential harm or a situation with a potential to cause loss.

(Australian Institute for Disaster Resilience)

Note: The next iteration of this handbook will discuss **Anthropogenic** and **Socionatural** hazards in greater detail. This will include how to determine probability of occurrence, understanding the hazard characteristics in greater detail and how they may interact with the environment under assessment.

[2] Derived from UNISDR definition of hazards.

[3] Disaster Management Act 2003 – Section 16: Meaning of Event.

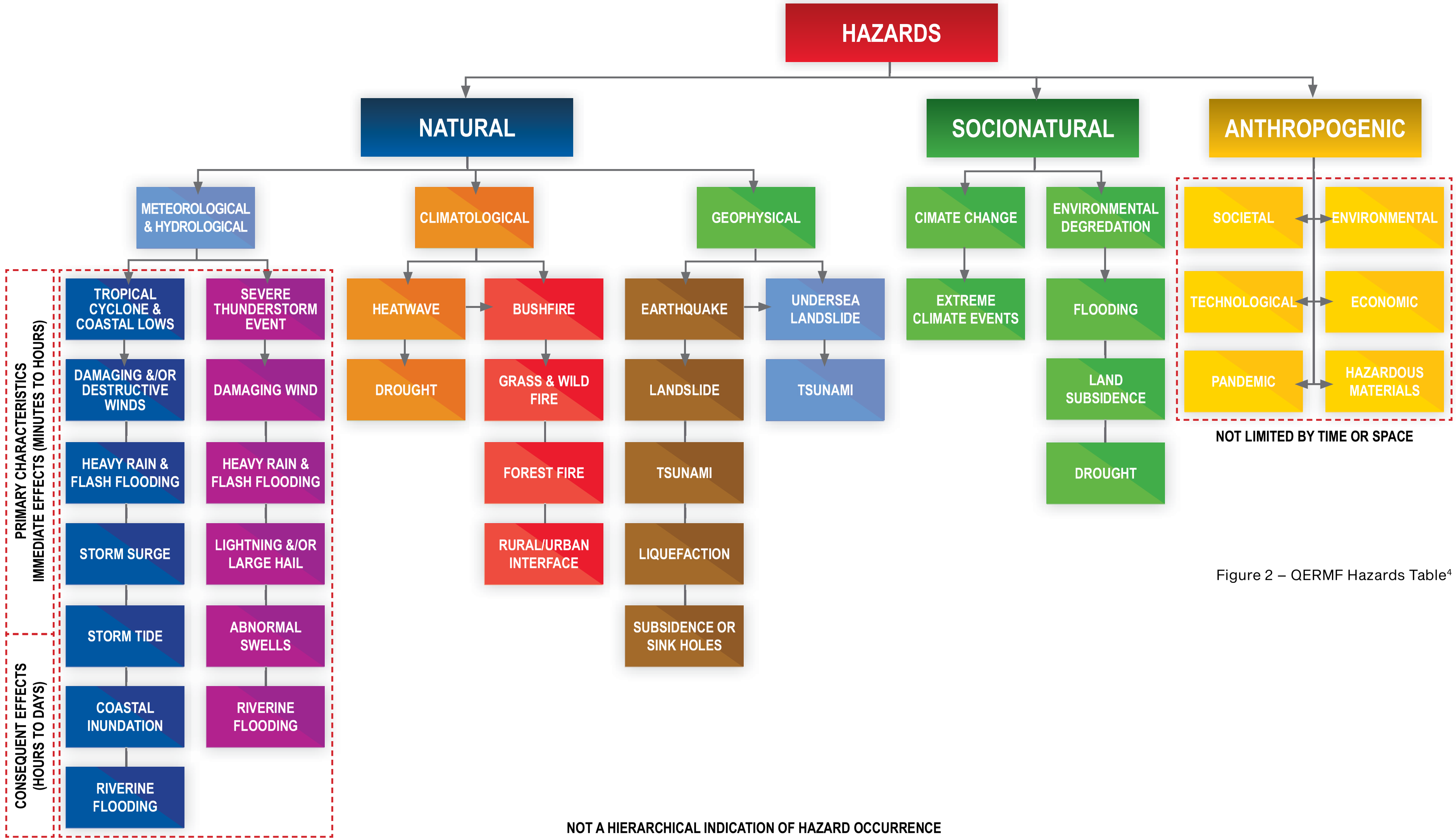


Figure 2 – QERMF Hazards Table[4]

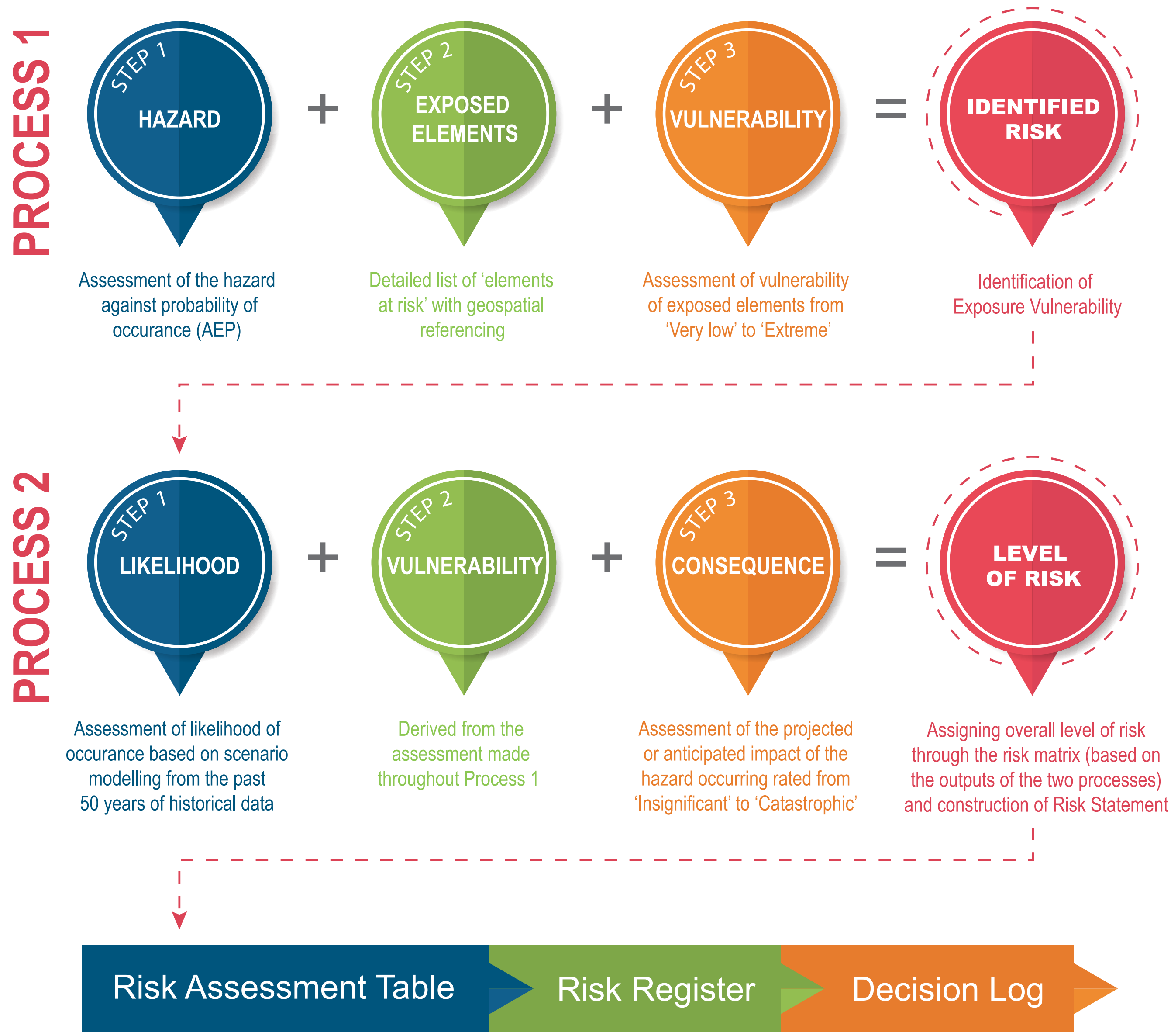
Natural Hazard – A dangerous natural event that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods and services, social and economic disruption and, or environmental damage is known as a natural hazard.

(United Nations Office for Disaster Risk Reduction)

[4] Terms derived from Australian Institute for Disaster Resilience, Geoscience Australia, BoM & Queensland Health.

Risk assessment process: snapshot

This risk assessment approach includes two key processes to identify the risk and then to assign the level of risk. The outcomes of these two processes are used to populate multiple risk management documents including the Risk Assessment Table, Risk Register and Decision Log. The process is outlined in the diagram below:



Process 1: Identifying risk

- Assess the hazard
- Detail the exposed elements (elements at risk)
- Assess the vulnerability of these exposed elements.

Process 2: Assigning level of risk

- Assess the likelihood (using scenario modelling based on the past 50 years of historical data)
- Identify vulnerability (drawn from Process 1)
- Assess the consequence
- Develop Risk Statements (for identified risks)
- Assign level of risk, and response:
  - Risk matrix and risk treatment options
  - Risk Assessment Table and Risk Register
  - Decision Log.

Why assess hazards using this methodology?

Risk assessment – an approach to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend.

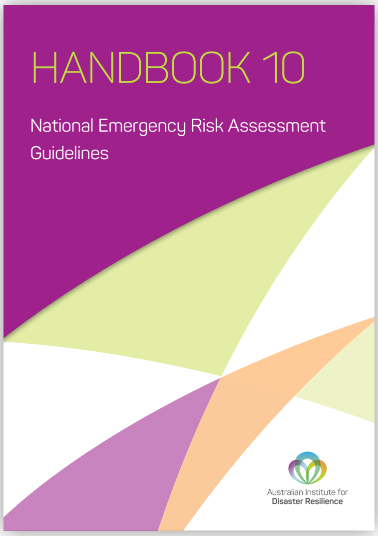
(United Nations Office for Disaster Risk Reduction)

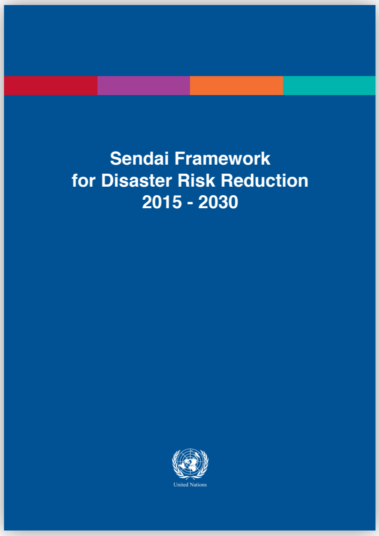
This assessment method provides a comprehensive and systematic approach to ensure that all potential risks are identified and recorded for the purpose of risk based planning.

Assessing risk using this methodology will assist in:

- gauging the probability that a hazard may manifest
- using geospatial analysis to determine where the hazard may manifest and what key local elements could be exposed to that hazard
- evaluating the effect of a hazard manifesting, based on the assessment of the severity of exposure and the level of vulnerability
- informing risk prioritisation, treatment, resource allocation and planning, and measuring this against the capability and capacity to manage the identified vulnerabilities.

The QERMF is derived from underpinnings of AS/NZS ISO 31000 International Standards and the National Emergency Risk Assessment Guidelines (NERAG) (Australian Emergency Management Institute, 2015), and embraces the Sendai Framework for Disaster Risk Reduction's (Sendai Framework) "Priorities for Action".





The QERMF also reflects international best practice as championed by the United Nations Office for Disaster Risk Reduction (UNISDR) and the Global Facility for Disaster Reduction and Recovery (GFDRR).

Finally, QERMF recognises the relevant elements within the Emergency Management Assurance Framework (EMAF) as published by the Office of the Inspector General Emergency Management, Queensland.

Risk assessment process: in detail

Process 1: Identifying risk

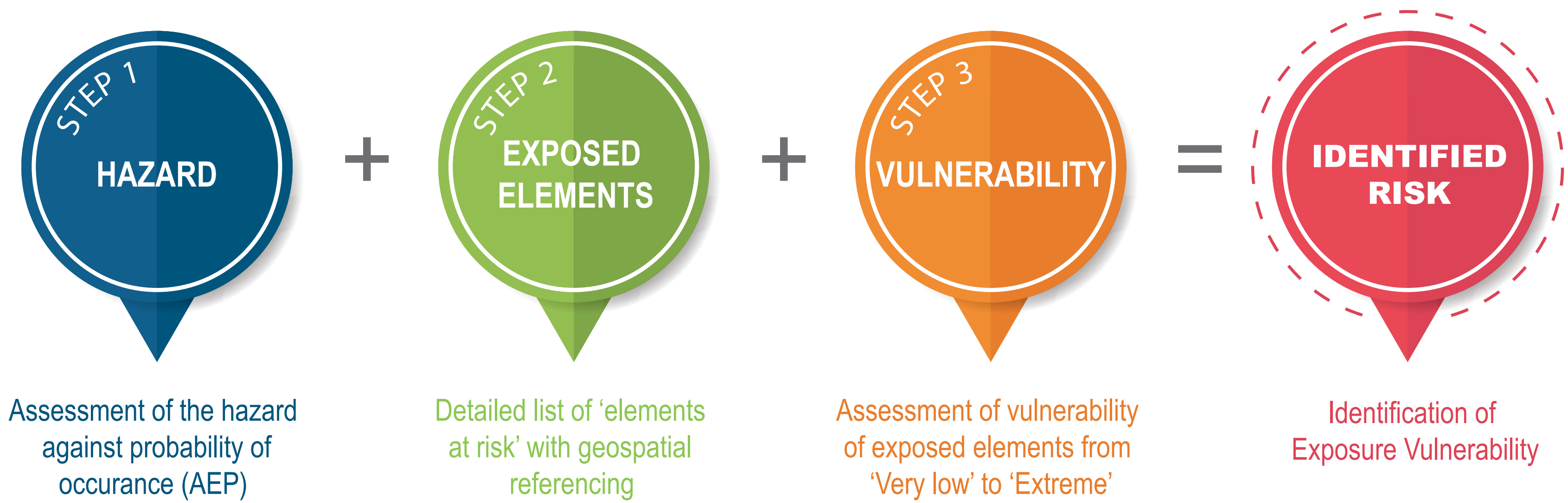


Figure 3 - Methodology for identifying risk

Process 1 allows for the initial identification of risk in relation to the probability of a hazard occurring versus its impact upon the natural and built environment within the area of assessment. This identified risk is further analysed throughout Process 2.

Step 1 HAZARD: assessing the hazard against the probability of occurrence

Disaster Risk – the likelihood (or probability) of loss of life, injury or destruction and damage from a disaster in a given period of time.

(United Nations Office for Disaster Risk Reduction)

Step 1 HAZARD considers the overall probability for a hazard to occur using the Annual Exceedance Probability (AEP).[5] This is the chance of the event occurring once in a year, expressed as a percentage (to determine likelihood).

The AEP is most commonly referred to in terms of flooding or rainfall events. However, it can be applied to all hazards, albeit with some caveats (discussed later in this document).

The AEP is used in this process instead of the Average Recurrence Interval (ARI). Use of ARI tended to cause confusion within risk based planning as it implied the associated magnitude or intensity of a hazard could only be exceeded at regular intervals (i.e. once in 100 years).[6] Assigning a probability factor or AEP to a hazard reduces the potential for confusion. Put another way, the AEP allows us to identify the probability of a hazard occurring in one year, whereas the ARI tended to infer that a certain hazard would only occur once every one, 10 or 100 years.

Table 1 below illustrates how AEP relates to previous occurrence indicators for natural hazards.

Likelihood	Annual exceedence probability (AEP)	Average recurrence interval (ARI) (indicative)
Almost certain	63% per year or more	Less than 1 year
Likely	10% to ‹63% per year	1 to ‹10 years
Unlikely	1% to ‹10% per year	10 to ‹100 years
Rare	0.1% to ‹1% per year	100 to ‹1000 years
Very rare	0.01% to ‹0.1% per year	1000 to ‹10,000 years
Extremely rare	Less than 0.01% per year	10,000 years or more

Table 1 - Probability table comparing AEP and ARI indicators (data sourced from NERAG, table created by QFES)

Why use probability when assessing risk?

While historical events are instructive in understanding the past, they do not necessarily provide a good guide to predicting the future. This is particularly pertinent in Australia, where our historical climatic catalogue is notably short and the world continues to deal with the increasing frequency and consequences of climate driven events. The use of probability in risk assessment – a ‘probabilistic risk assessment’ – helps to simulate the likelihood of future disasters based on increasing scientific evidence and understanding. (UNISDR [7], 2015)

[5] NERAG (2015): P70

[6] Bureau of Meteorology (2017). Why use AEP instead of ARI?

[7] United Nations International Strategy for Disaster Reduction.

Probabilistic risk modelling considers a 'full event set' spanning many thousands of years. This event set is built from the knowledge of historical events which can be reproduced based on the physics of the phenomena and its known impacts. Because this modelling is built on past occurrences, these events are not wholly representative of all possible events. This is why a full spectrum of events (with a range of associated likelihoods) must be considered in a risk assessment. In particular, where available, climate change projections should be included to reinforce modelling.

The use of probabilistic modelling in risk assessment does not exclude the benefits of scenario-based modelling. Indeed, probabilistic modelling can help to develop more robust and realistic scenarios by creating an amalgam of long term historic data with shorter term (50 years) localised activity. In this process, we use probabilistic modelling (running scenarios at different probabilities of occurrence) to generate assessments which comprise:

- Most likely – the losses that have most frequently and are most likely to occur
- Credible worst-case – the maximum possible loss as a result of a hazard that has occurred previously and may do so again.

Modelling scenarios based on the *Most likely* to *Credible worst-case* is the best practical basis for this process and the resulting assessment as this allows planners to focus resources and develop management and mitigation strategies for those scenarios most likely to occur and most likely to create the most loss. This approach is discussed further in Process 2, Step 1 LIKELIHOOD.

This is not an opportunity or endorsement for creating unrealistic scenarios that model the consequences of hazards that have no scientific basis for consideration. Rather, the process should only reflect the consequence of hazards that have a realistic chance of occurrence[8] based on scientific modelling and projection, in conjunction with the mathematical and methodical approach championed within this document.[9]

Indeed, Process 2, Step 1 LIKELIHOOD seeks to focus and fine-tune probability assessments by introducing a second assessment based on the meteorological and geological observations of the last 50 years (1967 - 2017) to factor in the greater uncertainty caused by climate change.

*** Resource for use: A guide on how to calculate AEPs for hazards on a District by District basis is included at Appendix 1.**

[8] Occurrence in this context refers to the period from point of assessment out to 2030 (as per advice from Geoscience Australia & in line with current Federal Government policy).

[9] Assessment of probability of occurrence in relation to geological processes i.e. earthquakes should be derived from consultation with Geoscience Australia.

Step 2 EXPOSED ELEMENTS: identifying the elements at risk

Exposure – elements within a given area that have been or could be, subject to the impact of a particular hazard. Sometimes referred to as the 'elements at risk'.

(Australian Emergency Management Institute)

Step 2 EXPOSED ELEMENTS considers those elements at risk (people, systems, networks and assets) which are vital to the area of interest that may be exposed to the hazard in the event of its occurrence.

It is not an analysis of the vulnerability or consequence of a hazard impacting these elements at risk but is simply the detailed identification of those that may be exposed if and when a hazard manifests.

Elements to consider may include:

- Essential infrastructure:
  - power (e.g. HV and LV transmission lines, circuit towers, sub-stations, generators)
  - communications (e.g. mobile towers, NBN infrastructure, phone lines)
  - water (e.g. reservoirs, water mains pipes, pump stations, sewerage treatment plants)
  - transport infrastructure (hubs such as airports, heliports, ports and ferry terminals)
  - fuel infrastructure (e.g. oil & gas pipelines, bulk fuel storage, oil & gas terminals).
- Access/resupply:
  - roads (e.g. National Highways, State Strategic Roads, Regional Roads, District Roads)[10]
  - rail (e.g. freight, light and heavy rail)
  - air (e.g. domestic and international, aerodromes, heliports, defence)
  - maritime (e.g. ports, ferry terminals, river crossings).
- Community and social:
  - population centres (e.g. villages, towns, cities)
  - demographics (vulnerable persons, medically dependent people, young or elderly people, people from non-English speaking backgrounds)
  - social infrastructure (e.g. schools, youth centres, community centres)
  - centres of governance (e.g. town halls, council offices)
  - building stock (e.g. precode-1980 buildings, post-1980 building stock)
  - emergency shelters
  - cultural elements (areas or objects of cultural or religious significance).
- Medical:
  - hospitals
  - clinics
  - aged care facilities.

[10] Classifications derived from Queensland's Department of Transport and Main Roads

- Significant industries:
  - heavy industry and manufacturing
  - transport and logistics
  - agriculture
  - tourism
  - local or other significant industries.
- Environmental:
  - local species and ecosystems
  - Areas of Ecological Significance (AES).

This list is not exhaustive and will not apply to all areas. Professional judgement coupled with extensive stakeholder engagement should be used when analysing the elements that may be exposed if a particular hazard manifests.

Once all exposed elements have been identified, it is important to use geospatial referencing to map the locations and the interdependencies of these elements. This is an essential step in assessing the impact of hazards upon the elements – and in particular the networks and systems relevant to their effective and efficient functioning – across broad areas. An example is provided in Figure 4.

Most of the relevant information pertaining to essential infrastructure will be held by system, network and asset owners or operators such as local governments and government-owned corporations or agencies.

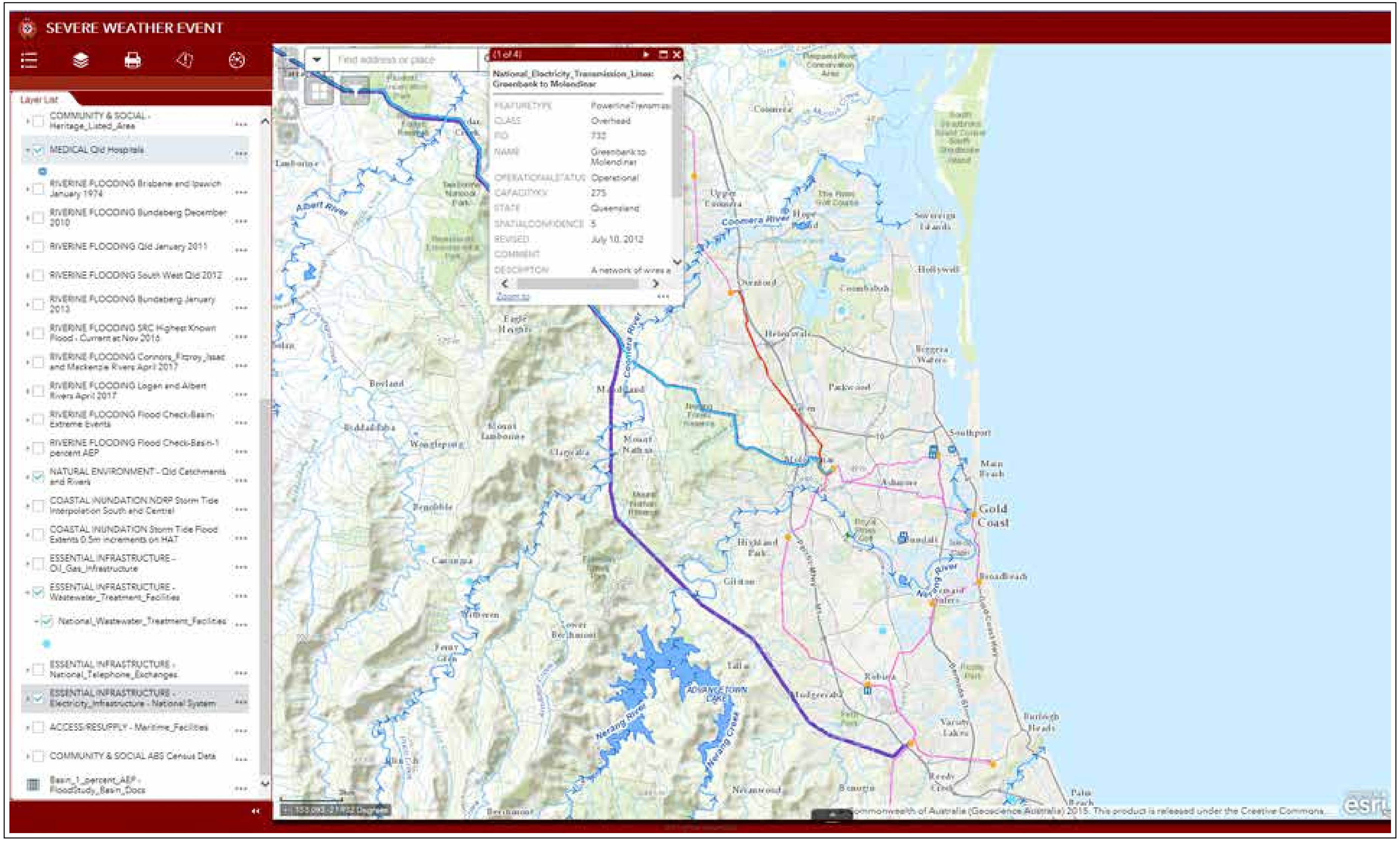


Figure 4 - Geospatial overlay (ArcGIS) of Gold Coast Disaster District highlighting essential power and water infrastructure against river catchments and basins (layers sourced from Bureau of Meteorology and QSpatial, map created by QFES)

Step 3 VULNERABILITY: assessing the vulnerability of exposed elements

Vulnerability – the characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard.

(United Nations Office for Disaster Risk Reduction)

Step 3 VULNERABILITY assesses the level of vulnerability of exposed elements. The identification of vulnerability is a direct precursor to identifying risk. Including vulnerability in the methodology allows for the analysis of individual characteristics of a community and ensures all risk management planning is 'fit for purpose' for that particular area. Conversely, risks to a particular community can be reduced by addressing these identified vulnerabilities.

In this process, vulnerability is categorised using a precise and factual assessment of the level of susceptibility, the ability to sustain a community during and post an event, and the effectiveness of current control and mitigation measures.

The assessment includes consideration of:

- loss of essential infrastructure and recovery timeframes
- repair/rebuild timeframes of essential infrastructure
- access/resupply to/or evacuation from the area/community/site
- topographic features of the area/community/site that exacerbate the impact of a hazard
- demographic features of the area/community/site that typify the population as vulnerable
- health support services available in the area/community/site
- effectiveness of current control or mitigation measures.

The identified vulnerabilities must be documented in a table, provided at Appendix 5. This table helps to define the key elements to consider in terms of how susceptible an element and ultimately the community is to a hazard manifesting in the area.

Geospatial (GIS) analysis of vulnerability based on topographic features (i.e. the geography of the landscape) and geomorphology is a useful first tool when assessing the impact of natural hazards, such as a severe weather event (tropical cyclone or severe thunderstorm) on exposed elements. For example, low-lying areas near a river are vulnerable to flooding while valleys with steep slopes may be vulnerable to landslides during heavy rain.

Generally, vulnerability based on topographic features and geomorphology will vary from hazard to hazard but considering these can be useful when it is difficult to access reliable data for assessing the probability of a hazard occurring. That is, if it is difficult to make an assessment of probability of occurrence, the effects of "known events" (i.e. those that have occurred within living memory) can still be simulated or modelled to better inform those assessments.

Within this phase of the risk assessment process, essential infrastructure can also be identified through geospatial analysis of your area – layers within GIS mapping (open source or derived through consultation with infrastructure owners and operators) can provide detailed information on essential infrastructure. Given that Queensland's Disaster Districts tend to be intersected with systems and networks (e.g. power, water, communications) and Local areas tend to be the terminus of such networks, the potential impact of a hazard on these interlinked networks needs to be considered in detail as part of the planning process.

As an example, identifying the vulnerability of vital transport and supply networks (i.e. road, rail and air) helps to determine the anticipated impact to the community in the event of a hazard occurring. This is commonly known as *Disruption-Related Risk.*[11]

Example: A case to consider about the disruption a hazard can have on a network is the South Australia power outage which occurred on 28 September 2016.

The outage, which affected 850,000 customer connections (state-wide) at its peak, was as a result of a sequence of events which occurred within one 88 second period.

However, one significant reason for the outage was damage to 23 pieces of critical power infrastructure caused by a severe thunderstorm which included high winds (including tornados), rain and lightning.[12/13]

*** Resource for use: Standardised definitions of vulnerability are provided in the Vulnerability Table at Appendix 2.**

[11] AS/NZS 5050:2010 Business continuity – Managing disruption-related risk.

[12] Climate Council of Australia (December 2016). Super-charged Storms in Australia: The Influence of Climate Change.

[13] Australian Energy Market Operator (October 2016). Update Report – Black System Event in South Australia on 28 September 2016.

Process 2: Determining level of risk

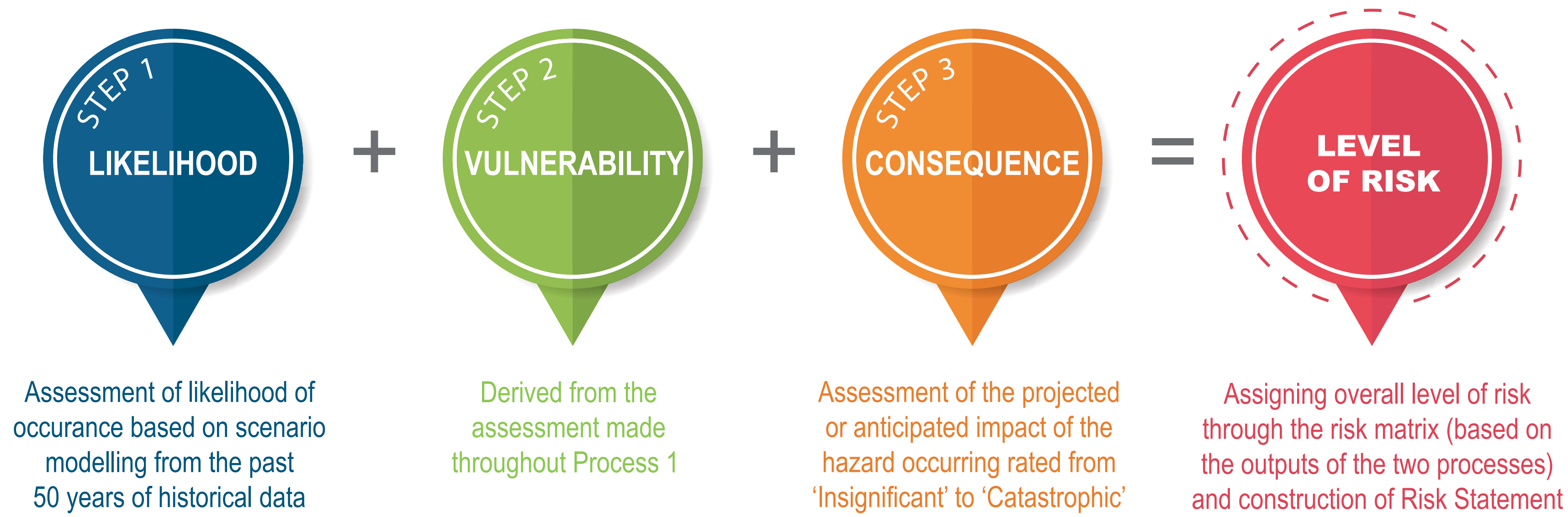


Figure 5 - Methodology for assigning level of risk

Process 2 allows for greater analysis of the identified risk which will ultimately lead to assigning a detailed level of risk. Assigning such a level allows for the prioritisation of limited resources and helps to inform decision making regarding certain courses of action or treatments of risk.

Step 1 LIKELIHOOD: assessing the likelihood of occurrence

Likelihood – the chance of something happening whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively and described using general terms or mathematically.

(Standards Australia/Standards New Zealand Standard Committee)

The key imperative of Step 1 LIKELIHOOD is to help disaster management practitioners identify the most credible likelihood of an event occurring, based on historical data.

This step relies on using the Likelihood Table (Table 2) which was developed specifically for this handbook using multiple sources including the Australian Institute for Disaster Resilience and Geoscience Australia. This table provides rankings based on the frequency and severity of hazards using the past 50 years of meteorological and geological observations. The same system can be applied to anthropogenic hazards.

The information specific to your area of interest can be derived from local area observations and relevant agencies such as the Bureau of Meteorology and Geoscience Australia.

With regards to natural hazards, this approach allows planners to focus on more recent patterns, recognising the changing environment and frequency of occurrence of severe weather events.[14]

Further, it allows the assessment of multiple possibilities without relying solely on using the Annual Exceedance Probability (AEP) discussed in Process 1, Step 1 HAZARD.

Likelihood Table		
Historical Likelihood	**Likelihood Level**	**Definition**
Has occurred 3 or more times in the last year or at least each year over the last 5 years	**Almost Certain**	Almost certain to occur in most cases
Has occurred twice in the last 5 years	**Likely**	Likely chance of occurring in most cases
Has occurred twice in the last 10 years	**Possible**	Might occur in most cases
May occur, and has occurred once in the last 20 years	**Unlikely**	Not expected to occur in most cases
May only occur in exceptional circum-stances or has occurred only once in the last 50 years or more	**Rare**	Will only occur in exceptional circumstances and has not occurred in most cases

Table 2 - Likelihood Table

[14] 50 year timeframe has been assigned based on the availability and quality of data across the hazards most prevalent throughout Queensland. This has been done in consultation with the Australian Institute for Disaster Resilience, Geoscience Australia and the Queensland Reconstruction Authority.

Using the Likelihood Table and geospatial analysis of data sourced from relevant agencies (such as the Bureau of Meteorology and Geoscience Australia), the assessment of the likelihood of occurrence is achieved by following four stages (an example of which follows):

1. Analyse the number of manifestations of a particular hazard and the levels of severity[15] which have occurred over the last 50 years within the area of assessment.
2. Identify the most frequent level of severity of occurrence within the area of assessment over the past 50 years to derive the *Most likely* scenario.
3. Establish the most severe level of occurrence within the 50 year period to derive the *Credible worst-case scenario.*
4. Assign the level of likelihood to both scenarios using the first column of the Likelihood Table. This will assign a level of risk of likelihood to the identified risk of between *Rare to Almost Certain.*

Example: A District under assessment finds that it has been impacted by 30 cyclones of varying intensity and duration during the past 50 years. Following the stages outlined above, the assessment shows:

- Twenty-one (or 70%) of those cyclones were rated as Category 2. Therefore, this is the *Most likely* level of severity of occurrence.
- The most severe cyclone to impact the District was a Category 4. Therefore, this is the *Credible worst-case* scenario.
- In looking at the Likelihood Table (above) the assessment shows that the *Most likely* scenario has occurred twice in the past five years and therefore is rated as *Likely.*
- Assessment of the *Credible worst-case* scenario shows that it has occurred once in the last 20 years and therefore is rated as *Unlikely.*

By narrowing the likelihood aspect to the 50 year timeframe, disaster management planners can factor in climate change adaptation, an increasingly complex and problematic phenomena. Modelling the *Most likely* and *Credible worst-case* likelihood scenarios allows planners to evaluate and review their capability and capacity, which will inform responses to identified risk.

Once again, the need to apply professional judgement during this assessment remains critical. If climate science data and projections are available, are relevant to the assessment and endorsed for use, then they should also be taken into consideration.

Note: Unlike other hazards, geological hazards such as earthquakes cannot be forecast with a degree of accuracy. Historic records provide an indication of recent seismicity (frequency, intensity and distribution of earthquakes) which may not be an indicator of future seismic activity. A measure of probability of occurrence can be derived from a detailed understanding of the relevant geological and geophysical processes that effect Australia in consultation with relevant agencies.[16]

During the risk assessment, if a Local or District planner identifies the need for further evaluation of the potential geological hazards within their area, they should consult with the relevant agency for further specialist advice.

[15] As per Bureau of Meteorology or Geoscience Australia definitions.

[16] Geoscience Australia (2017). Where do Earthquakes Occur?

Step 2 VULNERABILITY: finalisation of vulnerability assessment

> ***Vulnerability to natural hazards is an integral factor in understanding the true extent of risk.***
>
> *(Geoscience Australia)*

Step 2 VULNERABILITY involves the review and finalisation of the exposure vulnerability assessment made as a result of Process 1 as a precursor to the assessment of the level of consequence of an event.

No alteration to the initial level of vulnerability based on likelihood should be made as the vulnerability of an element remains constant whether the hazard occurs regularly or not.

The level of vulnerability should only be reassessed if:

1. existing controls are in place to mitigate identified vulnerabilities of exposed elements and/or
2. a risk mitigation strategy becomes apparent during consultation with an owner or operator of an asset or network during the planning cycle.

Effectiveness of current controls and mitigation measures

The final component of assessing vulnerability comprises stakeholder engagement with owners and operators of the identified system, network or asset at risk to undertake an informed review of current control or mitigation arrangements including:

- preparedness for an event (plans, processes, resources and capabilities)
- the level of redundancy and the impact of rebuilding should the hazard manifest
- supporting plans and arrangements.

The effectiveness of these controls – including the length of time required for such controls to be implemented or the anticipated timeframes involved for restoring or resuming of any disrupted service – must be identified. Discussions with stakeholders will play an essential role in determining the impact the outage of a particular infrastructure asset will have on the community.

For example, if communications infrastructure or an electricity distribution network is exposed to a hazard and is inoperable for an extended period, what would the duration of the outage be? It is necessary to consider redundancy: how long it would take to repair or rebuild and what percentage of the population relies on that piece of infrastructure or network?

Example: Revisiting the South Australia power outage example, full restoration of power to affected communities took more than 48 hours and much of the infrastructure was replaced by temporary measures which will be used for six to 12 months.

A secondary state-wide blackout affecting 155,000 connections occurred on 27 December 2016 when a severe thunderstorm caused damage to over 350 powerlines, many of which had been repaired or replaced after the September event.

This example highlights how easy it can be for an essential service to be compromised and the challenges in getting it restored in a timely manner, and in line with community expectations. It also highlights the vulnerability of the temporary infrastructure and the need to ensure interim measures provide an optimal solution.

Treatment options for the identified vulnerability will be discussed after the assessment has been completed and will be detailed and recorded within the Risk Register and Decision Log (discussed later in this handbook).

When a highly vulnerable piece of infrastructure is identified, it is essential to consult with the owner and operator of the infrastructure to identify and assess their mitigation or control measures. If no measures are in place, this would lead to a high vulnerability rating and act as a red flag for the purposes of planning. It would also be an impetus to encourage and assist the infrastructure owner and operator to develop and implement an appropriate mitigation measure.

Critical infrastructure, significant industries and business continuity management

> ***Critical infrastructure – those physical facilities, supply chains, information technologies and communication networks which, if destroyed, degraded or rendered unavailable for an extended period, would significantly impact the social or economic wellbeing of the nation or affect Australia's ability to conduct national defence and ensure national security.***
>
> *(Government of the Commonwealth of Australia)*

The vulnerability of critical infrastructure and significant industries are often considered through discrete processes such as Business Continuity Management (BCM) or disruption related risk assessments due to the fact that disruptions to these infrastructure and industries can have serious short and long term implications for business, governments and communities.

Current Standards such as AS/NZS 5050: 2010 describe the application of the principles, framework and process for risk management, as set out in AS/NZS ISO 31000: 2009, to disruption related risk. Owners and operators of critical infrastructure and significant industries currently undertake analysis of disruption related risk through a thorough risk assessment prior to the completion of a Business Impact Assessment (BIA).

The risk assessment process within this handbook can assist in defining and prioritising a number of disruption scenarios, which in turn will assist in analysing:

- vulnerabilities of the systems, structures and locations in which business activity occurs
- organisations' capability and capacity to manage any vulnerabilities
- dependencies and interdependencies
- knock on effects of "consequences" including cascade and cumulative effects.

Overall, the Business Impact Assessment for critical infrastructure and significant industries should reveal:

- processes, capabilities, infrastructure and other resources which if disrupted would prevent achievement of critical business objectives
- the level of vulnerability of processes and capabilities
- priorities for action.

Risk treatment for critical infrastructure and significant industries

Treatment options fall into two broad categories for both risk assessments and disruption related risks:

1. Proactive approaches involving prevention and protection (preparedness) measures which may influence the potential and/or scale of disruptive events.
2. Contingency plans and contingent capability (response) to minimise the impact on critical objectives by a potentially disruptive event.

Development of contingency plans and contingent capability can assist to eliminate, reduce and stabilise the impacts of events, restore or continue critical business functions (objectives), and expedite restoration of normalcy (recovery).

Communication and cooperation between the owners and operators of critical infrastructure and significant industries with their respective level of the QDMA is key to the development of realistic, responsive and effective plans.

Step 3 CONSEQUENCE: assessment of the likely impact

Consequences – the outcome or impact of an event that can be expressed qualitatively or quantitatively. There can be more than one consequence from an event.

(Geoscience Australia)

Step 3 CONSEQUENCE determines the level of consequence of an event – the impact based on the assessment of severity of exposure and the level of vulnerability.

The level of consequence is an assessment of what the projected or anticipated impact would be, either directly or indirectly, of the hazard manifesting on Local, District and State assets. These may be short term and longer term impacts in duration (i.e. weeks, months, years) depending on the severity of the impact.

In assessing exposure and vulnerability we can determine the level of impact of a hazard manifesting by identifying key features of a community that include:

- people (casualties) – the number of casualties and fatalities
- financial and economic – impacts to the Queensland economy, which may include a decline of economic activity (over months or years) or a decrease in government revenues from critical and essential infrastructure and significant industries
- community and social – destruction or damage to objects or places of cultural and religious significance and community cohesion (e.g. churches, community centres)
- public administration – governing bodies' ability to cope within response and recovery phases and the resulting level of public confidence and media criticism
- environmental – damage or destruction to natural resources, ecosystems or species (e.g. Great Barrier Reef).

Note: In assessing the level of impact or consequence, consideration should be given to the fact that an impact on one area may have a direct or indirect impact on another. This is known as the *Consequence Wheel,* shown in Figure 6.

To assess and classify the consequence, a Consequence Table has been developed for this handbook and is located at Appendix 3. The levels of assessment range from *Insignificant* to *Catastrophic* for each of the five features listed prior (people, financial and economic, community and social, public administration and environmental).

While the criteria and levels provided are derived from NERAG 2015, some aspects of the criteria such as 'People (casualties)' and 'Financial and economic' assessments have been developed based on the Australasian Triage Scale[16] and advice from Queensland Treasury.[17] These criteria and levels apply across all levels of the QDMA.

[17] Descriptors based on the Australian College For Emergency Medicine (ACEM) – Guidelines on the implementation of the Australasian Triage Scale in Emergency Departments, November 2013.

Note: An important caveat to assigning an overall level of consequence is that a hazard may manifest and impact across several of the categories detailed above but some impacts may be more severe than others. As such, the overall level of consequence should be assigned based on the highest rated impact in order to plan and mitigate against all possible outcomes. Once again, professional judgement should be applied and/or key stakeholder engagement undertaken.

* **Resource for use: To assess and classify the consequence, a Consequence Table is located at Appendix 3.**

Figure 6 - Consequence Wheel

Risk Statement development

After assessing the vulnerability, evaluating the effectiveness of controls and identifying consequences to the elements at risk, a Risk Statement should be completed to aid the future composition of the Risk Assessment Table and Risk Register. The Risk Statement seeks to focus the disaster management practitioner on the "what if?" aspects of the assessment. It also helps to rationalise the future assessment of consequence within *Process 2: Determining the level of risk*. Risk statements provide further context for developing risk treatments by concisely detailing the cause of the risk and its anticipated effects.

The following information should be identified when developing risk statements:

- the hazard and its characteristics
- what, who and where may be impacted (exposed elements)
- a description of the impacts from the hazard manifesting (vulnerability)
- any control or mitigation measures in place (short and medium to long term)
- the anticipated duration of impact (short and medium to long term).

Example: This is an example of a Risk Statement –

"Essential infrastructure sites (especially power & water) are highly vulnerable to the manifestation of a Tropical Cyclone, especially Severe Tropical Cyclones (Category 3-5).

District electricity distribution network is highly vulnerable to high winds and flash flooding with limited redundancy to maintain the service.

Critical civic infrastructure such as hospitals and water treatment plants highly susceptible to power outages and can only rely on back up generation for 24 hours before resupply is needed.

Short to medium term disruptions to power, communications and safe drinking water to communities across the District. Secondary hazards such as storm surge and associated torrential rain may occur and further disrupt essential infrastructure located within the coastal areas of the District."

* **Resource for use: Further example risk statements can be found within the fictionalised case study provided at Appendix 5.**

Assigning the level of risk

Risk level – magnitude of risk or a combination of risks, expressed in terms of the combination of vulnerability, consequence and their likelihood.

(Australian Institute of Disaster Resilience)

After completing each step of Process 2 *(Likelihood, Vulnerability* and *Consequence)* an overall level of risk can be calculated and assigned.

The Risk Matrix used in this process (Table 3 and expanded at Appendix 4) inputs the likelihood (X), vulnerability (Y) and consequence (Z) levels (ranked 1-5 respectively) to output an overall severity rating (1-13). The severity rating is then broken down across five levels of risk which range from *Very Low to Extreme.*

	Likelihood (X)	Rare (1)					Unlikely (2)					Possible (3)					Likely (4)					Almost Certain (5)				
	Vulnerability (Y)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)
Consequence (Z)	INSIGNIFICANT (1)	VL1	VL2	VL3	L4	L5	VL2	VL3	L4	L5	L6	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9
	MINOR (2)	VL2	VL3	L4	L5	L6	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10
	MODERATE (3)	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11
	MAJOR (4)	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11	M8	H9	H10	H11	E12
	CATASTROPHIC (5)	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11	M8	H9	H10	H11	E12	H9	H10	H11	E12	E13

Key: V.L= Very low; L = Low; M = Medium; H = High; E = Extreme

Scale: 1 (lowest) to 13 (highest)

Table 3 - Risk Matrix

Awarding an overall level of risk seeks to aid planners in determining the prioritisation of future responses and resources.

Example: An assessment has been completed of a possible tropical cyclone event in the fictional Disaster District of Kangerooville in which the likelihood of a tropical cyclone was rated *Possible (3)*; but the vulnerability of exposed elements was classified as *High (4)* with the resultant consequences categorised as *Major (4)*. Using Risk Matrix, this would equate to an overall *High 9 (H9)* risk level for a tropical cyclone in Kangerooville (as highlighted in the red quadrants in Table 3 Risk Matrix).

The initial level of risk – known as the inherent risk – is derived from the Risk Matrix and it is highlighted in the Risk Assessment Table and Risk Register as part of the finalisation of the risk assessment process.

Risk levels are used to assess the best strategies for mitigating or controlling risk and seek to identify response options and allocation of resources.

The level of risk will only change once control measures have been applied to the elements at risk (as discussed within the vulnerability assessment in Process 2, Step 2 VULNERABILITY).

* **Resource for use: A risk matrix for assigning risk levels is located at Appendix 4.**

Risk treatment

Risk treatment strategies aim to determine and implement the most appropriate actions to treat (control or mitigate) the identified inherent risk. These actions typically comprise both short and longer term strategies to address immediate impacts and the resultant ongoing issues.

(When identifying strategies, it is important to prioritise responses to inform decisions about what is to be done, when and by whom. This requires understanding of attributes such as urgency, controllability and response effectiveness in order to execute the actions effectively and in a timely manner for the best return on available resources.)

Once treatment of risk measures have been identified, planned or put into place, it is important to then consider the *residual risk.*

Residual risk – the risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained.

(United Nations Office for Disaster Risk Reduction)

Residual risk is the risk that is beyond the capability and/or capacity of the Local or District community or communities and existing disaster management arrangements to treat or mitigate.

Residual risk must either be accepted as tolerable or should be transferred to and/or shared across the next level of the disaster management arrangement (upon consultation). This will allow for the residual risk to be understood and treatment or mitigation measures to be developed as per the Risk Planning Equation shown later in Figure 7.

The two examples below seek to illustrate the complexities of residual risk management:

Example 1: A Local Disaster Management Group has the capability to evacuate people from a specific impact area if required but their capacity to do so is limited to approximately 500 people per hour (for a maximum of six hours). Therefore, if 3000 vulnerable people required evacuation within a four hour timeframe (750 people per hour for four hours) the Local Disaster Management Group would have a capacity gap of 250 people per hour. This is the residual risk. Therefore, management of this capacity gap would require additional resources (capacity) to be provided (transferred) from the next level of the disaster management arrangement.

Example 2: Another Local Disaster Management Group identifies that it has no capability (and by extension no capacity) to evacuate people if required. Thus, no mitigation measure is available at the Local level and the capability must be provided (transferred) in its entirety from the next level of the disaster management arrangement.

Note: Residual risk can also be shared horizontally across the disaster management arrangements. For example, if a local government – through the Local Disaster Management Group – identifies they have the capability to respond to an event that is beyond other local governments within the District they may elect to share that capability in a pan-local government arrangement.

Risk Based Planning Equation

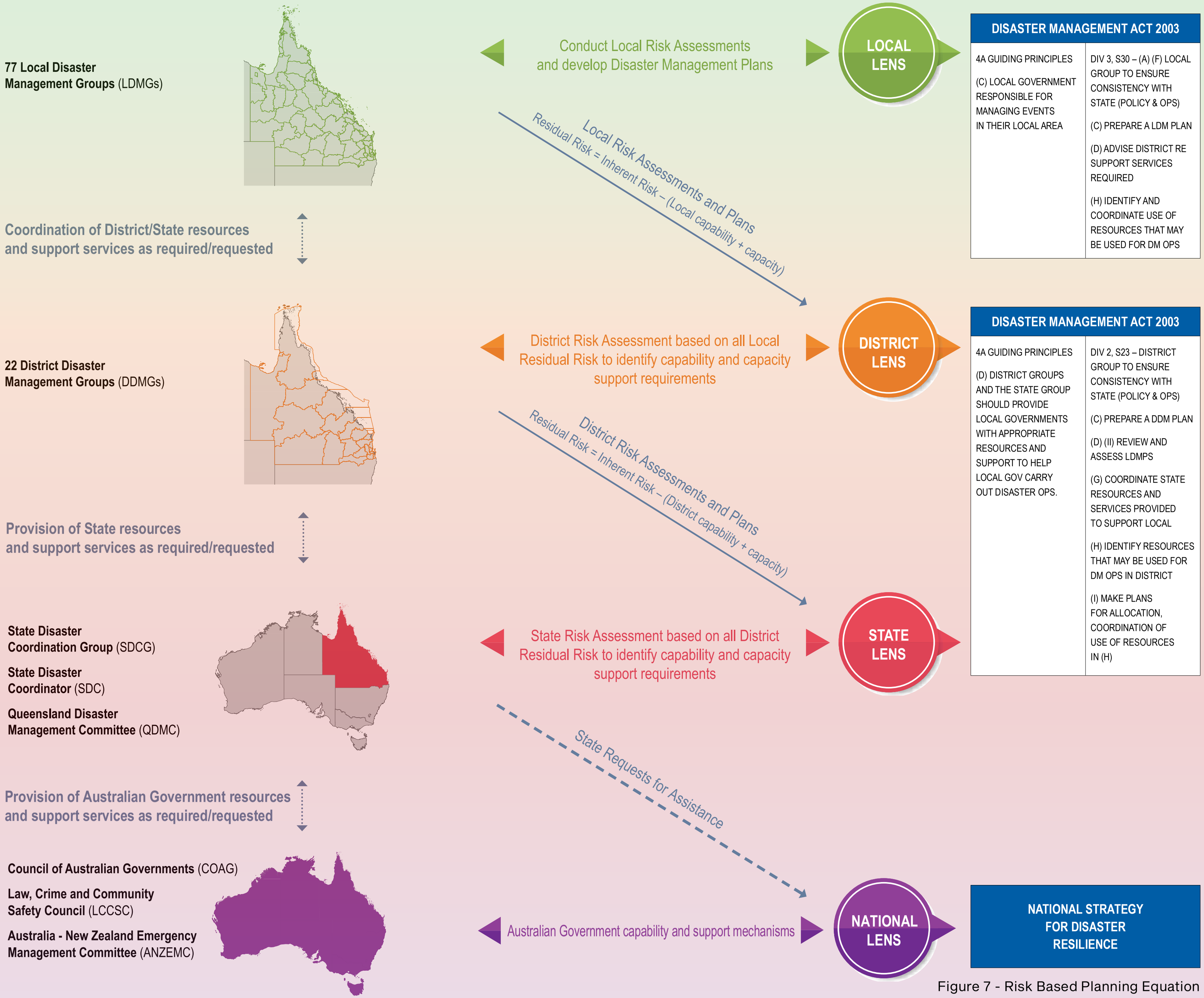


Figure 7 - Risk Based Planning Equation

Risk documentation

This section outlines the key documentation needed to effectively identify and manage risks, which are:

- Risk Assessment Table – records all the hazards identified, considered and addressed
- Risk Register – outlines the risks that require attention and treatment options for further action
- Decision Log – outlines and records 'key decisions' in the assessment of risks.

All three tables including the Decision Log have the ability to numerically record and track key decisions throughout the risk assessment process.

Risk Assessment Table

The Risk Assessment Table is used to record all the hazards considered, identified and addressed within the assessment process outlined in this handbook. Some matters considered within the Risk Assessment Table may not be recorded in the Risk Register if their consequences and subsequent treatment options are not considered significant enough for further consideration. However, this must be noted within the Decision Log.

The Risk Assessment Table should provide evidence that demonstrates the identification, assessment and future treatment of risk. It should contain the following key criteria:

- the hazard being assessed
- the probability of occurrence (derived from the AEP assessment)
- key elements that will be exposed if the hazard manifests
- a vulnerability rating for exposed elements (from *Very Low* to *Extreme*)
- a likelihood assessment level (from *Rare* to *Almost Certain*)
- existing risk treatments or controls (short and long term measures that exist to treat or control the risk)
- a consequence level (from *Insignificant* to *Catastrophic*)
- inherent risk level (risk level as a function of exposure, vulnerability and consequence)
- a Risk Statement (i.e. what is impacted, who is impacted and where is impacted).

* **Resource for use: An example of a completed Risk Assessment Table can be found at Appendix 5.**

Risk Register

Risk register – produced by risk assessment processes, summarising the outputs of these processes to inform decision making about risks.

(Australian Institute of Disaster Resilience)

The Risk Register outlines the risks that require attention and provides treatment options for further action. This additional action is vital to risk based planning and for transparency and accountability in the management of residual risk and the subsequent request for and provision of support if required.

A Risk Register should be prepared for each level of QDMA with the overall decision on the residual risk i.e. *Accept, Mitigate, Transfer* or *Shared*, clearly annotated at the end of the register. Remember, the decision to transfer residual risk can only be made based on the capability and capacity of Local, District and State levels to appropriately mitigate and treat that residual risk.

The example Risk Register provided at Appendix 6 demonstrates that, for each risk, the disaster Risk Register includes:

- a risk identification number – an alphanumeric identifier
- Decision Log reference number – linked to the Decision Log Table (Appendix 7)
- the hazard being assessed
- the exposed elements
- the Risk Statement
- inherent risk level
- existing risk treatment or controls
- Local and District capability and capacity to manage the identified risk
- capacity gaps (or residual risk)
- consequence rating (against the capacity gaps or residual risk)
- residual risk rating
- residual risk either accepted, mitigated or transferred or shared.

* **Resource for use: An example of how to complete a Risk Register can be found at Appendix 6.**

Decision Log

The Decision Log (refer Appendix 7) and any supporting documentation associated with a Risk Register is designed to outline and record key decisions in the assessment of risks, including the rationale behind judgements and decision, and who was involved.

The Decision Log should succinctly and efficiently capture critical attributes of the key decisions made during the risk assessment process, particularly where additional detail is required. In instances where the risk is transferred from or shared across one level to another, the rationale should be clearly outlined and justifiable. This allows for transparency in decision making and clearly outlines those involved in the process.

The Decision Log can and should accurately record the timeline for implementation of future risk treatment options. This should include:

- the date the plan for the risk treatment option was accepted
- the date for implementation
- details of the person, organisation or agency responsible for the implementation
- the date for review of progress towards implementation.

*** Resource for use: An example of a Decision Log can be found at Appendix 7.**

Action plan: risk assessment process

The below table summarises the entire risk assessment process as well as defining the resources to use and outputs that should be derived throughout each process and step, ultimately resulting in the development of a detailed, robust Risk Assessment Table, Risk Register and Decision Log.

Stage	Resources to use	Output	Outcome	
Process 1				Identified risk
Step 1 HAZARD				
Assess the hazard using the Annual Exceedance Probability (AEP)	Appendix 1 – Calculating Annual Exceedance Probabilities	Probability Rating	Contributes towards identifying *inherent risk* rating Used in Risk Statement	
Step 2 EXPOSED ELEMENTS				
Develop detailed list of elements at risk, with reference to local geospatial characteristics	Geospatial tools Consultation with all relevant stakeholders	Detailed list and understanding of exposed elements to the assessed hazard	Contributes to towards *inherent risk* rating Used in Risk Statement	
Step 3 VULNERABILITY				
Assess vulnerability of exposed elements	Geospatial tools Consultation with all relevant stakeholders Appendix 2 – Vulnerability Table	Vulnerability rating	Initial assessment of vulnerability (carried forward to Process 2) Used in Risk Statement	
Process 2				Level of risk
Step 1 LIKELIHOOD				
Assess likelihood of occurrence using scenario modelling from past 50 years data	Likelihood Table Consultation with local area experts and relevant subject matter agencies (e.g. Geoscience Australia, BoM)	Likelihood rating *(Most likely & Credible worst-case)*	Inputs into Risk Matrix to inform overall level of risk Recorded in the Risk assessment Table & Risk Register	
Step 2 VULNERABILITY				
Refer to Process 1, Step 3	Vulnerability rating from Process 1, Step 3 Consultation with all relevant stakeholders to identify any current control or mitigation measures	Finalised vulnerability rating	Inputs in to Risk Matrix to inform overall level of risk Recorded in the Risk Assessment Table & Risk Register	
Step 3 CONSEQUENCE				
Assess the projected impact of the hazard occurring	Appendix 3 - Consequence Table Consultation with all relevant stakeholders	Consequence rating	Inputs in to Risk Matrix to inform overall level of Risk Recorded in the Risk Assessment Table & Risk Register Used in Risk Statement	

Table 4 - Action plan

Appendix 1 Calculating Annual Exceedance Probabilities (AEP)

Communication with relevant agencies is critical throughout the risk assessment process. Professional consultation with subject matter experts adds rigour to risk assessments and risk based planning. As such, gathering data about the annual probability of occurrence should be done in consultation with the agencies that hold relevant data. For example, the Bureau of Meteorology holds occurrence data for tropical cyclones (cyclones), severe weather and flooding events.

However, much of this data is at a macro-level and therefore not available on a District by District basis. This has obvious consequences when considering hazards in areas that historically have not had a high frequency of occurrence but, due to a high frequency of occurrence elsewhere in the state, the AEP will be artificially skewed for that area.

For example, Far North Queensland has a very high frequency of occurrence of cyclones (>63% or *Almost certain*) but Charleville has a very low frequency of occurrence (<10% or *Unlikely*). However, using a state-wide assessment of cyclone occurrence would skew the assessment for Charleville to between >10% and <63% or *Likely*.

To resolve this issue, this Risk Assessment Process Handbook promotes the use of Geographic Information Systems (GIS) datasets to overlay historical climatic data onto Disaster Districts to allow for micro-level assessments. GIS datasets from organisations such as the Bureau of Meteorology, Geoscience Australia and State Government organisations have a high degree of accuracy and data confidence, and therefore provide a reliable Average Recurrence Interval (ARI) and subsequent AEP evaluation.

Figure 8 below shows an overlay of cyclones across Queensland over a 100 year period[18] focused on the Mackay Disaster District.

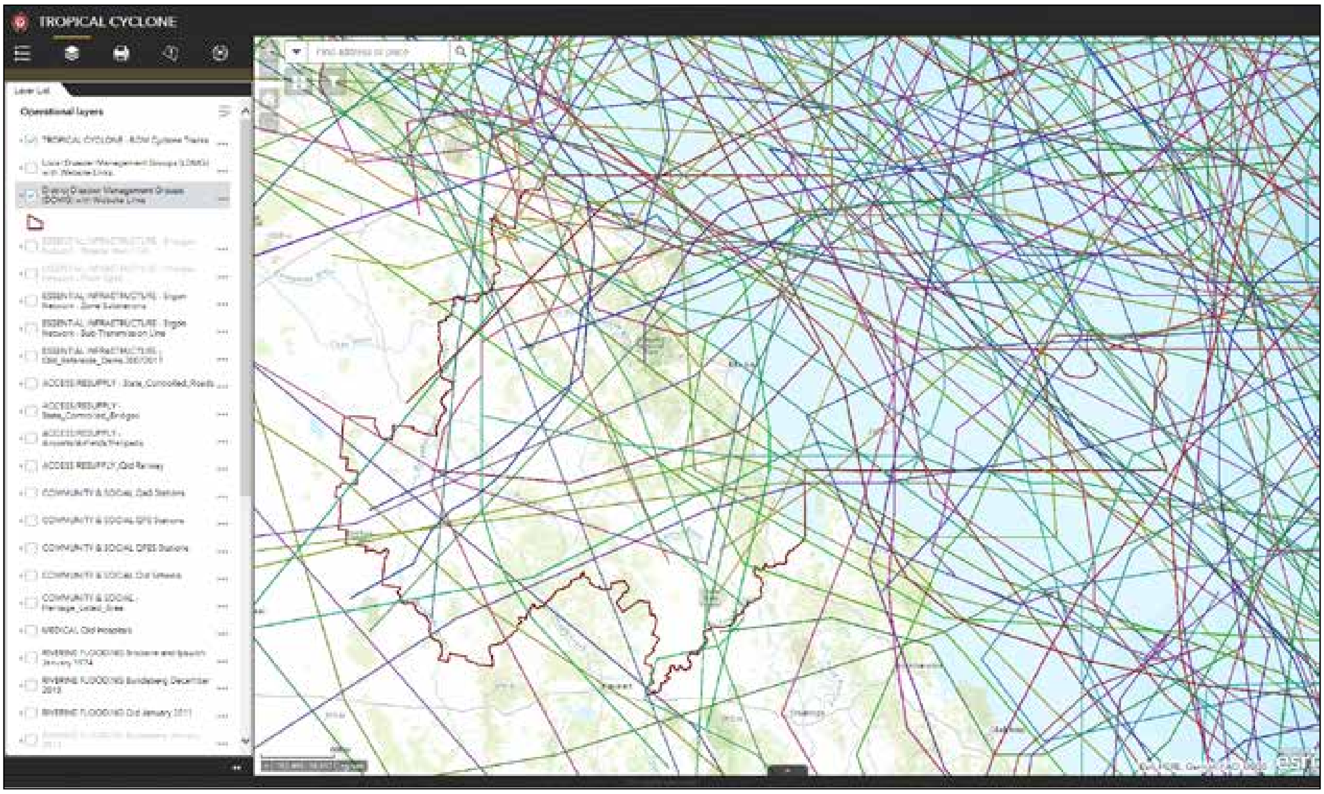


Figure 8 - Tropical cyclone data overlayed onto Mackay Disaster District (ArcGIS)

[18] 100 year timeframe refers to the time from which accurate capture and recording of cyclones tracking across Australia occurred.

Analysis of the dataset shows that within this period the District was impacted by 73 cyclones[19] of varying intensity and duration. Due to this data and analysis through geospatial tools it is possible to calculate the AEP for tropical cyclones in the Mackay District alone.

This is done through a two stage calculation:

1. Calculate the Average Recurrence Interval (ARI) using the following equation:

$$T = \frac{N}{n}$$

   Where:

   - *T* = the recurrence interval (expressed as 1 in *x* number of years)
   - *N* = the number of years in the set
   - *n* = the number of events within that set.

   In relation to the Mackay example above, *N* would equal 100 (the number of years of recorded data) and *n* would be 73 (the number of cyclones that have occurred within that 100 year period). Thus the ARI would be 1 in 1.37 years (or 1 cyclone every 1.37 years).

2. Convert the ARI in to AEP using the following linear equation.[20]

$$AEP = 1 - \exp\left(\frac{-1}{ARI}\right)$$

   For the purpose of the Mackay example the equation reads as follows:

$$1 - \exp\left(\frac{-1}{1.37}\right) = 0.51$$

   therefore
   0.51 x 100 = 51% AEP

Finally, using the probability table below (and discussed in Process 1, Step 1 HAZARD), we see an AEP of 51% equates to a qualitative likelihood rating of Likely as the probability of occurrence is greater than ›10% but ‹63%.

Likelihood	Annual exceedence probability (AEP)	Average recurrence interval (ARI) (indicative)
Almost certain	63% per year or more	Less than 1 year
Likely	10% to ‹63% per year	1 to ‹10 years
Unlikely	1% to ‹10% per year	10 to ‹100 years
Rare	0.1% to ‹1% per year	100 to ‹1000 years
Very rare	0.01% to ‹0.1% per year	1000 to ‹10,000 years
Extremely rare	Less than 0.01% per year	10,000 years or more

[19] "Tropical Cyclones" include Categories 1-5 and include those that have impacted on both land and sea, and those that impacted only at sea.

[20] The equation can be input to a scientific calculator, which is commonly available on most handheld devices and computers.
(AEP equation derived from E.M. Laurenson. 1987. Back to Basics on Flood Frequency Analysis. Civil Engineering Transactions.)

Appendix 2 Vulnerability Table[22]

Process 1, Step 3 & Process 2, Step 2 – Definitions of vulnerability	
Extreme	• Recovery from loss of essential infrastructure would be prolonged and complicated; the community is totally dependent upon the service with no "back up" operational infrastructure to service the community (e.g. water treatment plant, electricity and communications). • Repair / rebuild of essential infrastructure would take longer than one year (to previous service levels). • Access / resupply to or evacuation from the area / community / site is via one route (e.g. one road or bridge that floods with no possibility of air access). • The topographic features of the area / community / site have a direct relationship to a hazard (e.g. the area is highly concentrated with old housing that is low lying or is located in highly concentrated bushland). • The area / community / site is typified by significant numbers of vulnerable populations. These may include: medically dependent people (e.g. home haemodialysis), elderly or young residents (e.g. over 65 years or less than five years old), people from non-English speaking background and the unemployed. • The area / community / site has one health support service (e.g. hospital that has very limited capacity and no availability of specialised health professionals).
High	• Recovery from loss of essential infrastructure would be possible, however only in the long term for secondary "back up" operational infrastructure to service the community (e.g. water treatment plant, electricity and communications). • Repair / rebuild of essential infrastructure would take longer than several months (to previous service levels). • Access / resupply to or evacuation from the area / community / site is via very limited routes (e.g. air access only via one airfield or cleared areas for helicopter access). • The topographic features of the area / community / site are prone to a hazard (e.g. the area is typified by old housing that is low lying or is located in dense bushland). • The area / community / site is typified by large numbers of vulnerable populations. These may include: medically dependent people (e.g. home haemodialysis), elderly or young residents (e.g. over 65 years or less than five years old), people from non-English speaking background and the unemployed. • The area / community / site has limited health support service (e.g. hospital has limited capacity and very limited availability of specialised health professionals).
Moderate	• Recovery from loss of essential infrastructure is simple but requires time for secondary "back up" operational infrastructure to service the community (e.g. water treatment plant, electricity and communications). • Repair / rebuild of essential infrastructure would take longer than several weeks (to previous service levels). • Access / resupply to or evacuation from the area / community / site is via limited routes (e.g. there is one airfield and one access road). • The topographic features of the area / community / site are conducive to a hazard (e.g. the area is somewhat typified by old housing in some low lying areas or dense bushland). • The area / community / site contains some vulnerable populations. These may include: medically dependent people (e.g. home haemodialysis), elderly or young residents (e.g. over 65 years or less than five years old), people from non-English speaking background and the unemployed. • The area / community / site has some health support services available (e.g. more than one hospital or medical facility with limited capacity and a limited number of specialised health professionals).
Low	• Recovery from loss of essential infrastructure achievable in short term for secondary "back up" operational infrastructure to service the community (e.g. water treatment plant, electricity and communications). • Repair / rebuild of essential infrastructure would take less than one week (to previous service levels). • Access / resupply to or evacuation from the area / community / site is via several routes (e.g. there are several airfields and several access roads). • The topographic features of the area / community / site are somewhat conducive to a hazard (e.g. the area has negligible old housing located in low lying areas or dense bushland). • The area / community / site contains limited numbers of vulnerable populations. These may include: medically dependent people (e.g. home haemodialysis), elderly or young residents (e.g. over 65 years or less than five years old), people from non-English speaking background and the unemployed. • The area / community / site has several health support services available (e.g. several hospitals with the capacity to cope with surge and several specialised health professionals on duty or on call).
Very low	• Recovery from loss of essential infrastructure achievable within one day with a secondary "back up" operational infrastructure that would service the community (e.g. water treatment plant, electricity and communications). • Repair / rebuild of essential infrastructure would require less than one day (to previous service levels). • Access / resupply to or evacuation from the area / community / site is via multiple routes (e.g. there are several airfields and several access roads in and out of the area). • The topographic features of the area / community / site are not conducive to a hazard (e.g. the area has no old housing located in low lying areas or housing located in dense bushland). • The area / community / site contains little to no numbers of vulnerable populations. These may include: medically dependent people (e.g. home haemodialysis), elderly or young residents (e.g. over 65 years or less than five years old), people from non-English speaking background and the unemployed. • The area / community / site has multiple major and specialised health support services available (e.g. multiple large specialised hospitals with the capacity to cope with surge and multiple specialised health professionals on duty or on call).
Considerations	• Control or mitigation measures already in place or planned against the manifestation of a hazard will reduce the overall level of vulnerability. The information in relation to control or mitigation measures is gained through consultation with relevant stakeholders. • Analysis of "Vulnerable Populations" should consider the natural resilience – or "coping capacity" – of communities. • Analysis of "Vulnerable Populations" should consider the perception of the community towards the hazard. Is there an over- or under-estimation of the perceived risk? This may be due to media bias, previous experience or other contributing factors.

[22] The categories and descriptors within the Vulnerability Table (Appendix 1) are based on research from a range of sources including:
- Geoscience Australia (Geoscience Australia, 2007)
- ISO 31000 Handbook 167: 2006 Security Risk Management (Standards Australia/Standards New Zealand Standard Committee, 2006).

Appendix 3 Consequence Table

Process 1, Step 3 & Process 2, Step 2 – Definitions of vulnerability	People[23]	Financial & Economic
Catastrophic	Multiple fatalities and multiple critical injuries requiring evacuation to hospital and specialised care. These include life threatening injuries that require immediate aggressive intervention (e.g. injuries requiring specialised treatment or after care such as burns).	Permanent decline of economic activity or government revenues from industries (e.g. mining, agriculture, tourism). Loss or failure of an industry and / or loss of asset as a direct result of emergency event that requires Federal and State Government financial assistance. The recovery from the loss of essential infrastructure would be prolonged and complicated and require Federal and State Government financial assistance.
Major	Several fatalities with multiple critical injuries requiring immediate evacuation and hospitalisation. These injuries would include several imminent life threatening injuries requiring time critical treatment.	Longer term decline of economic activity (e.g. several years) or government revenues from industries (e.g. mining, agriculture, tourism). Significant structural adjustment of an industry and / or significant damage to an asset that requires Federal and State Government financial assistance. The recovery from loss of essential infrastructure would be possible through State Government financial assistance.
Moderate	A fatality and several critical injuries (e.g. those with an injury that requires immediate treatment and could be potentially life threatening) requiring hospitalisation within the local area hospital.	Medium term decline of economic activity (12 months or more) or government revenues from industries (e.g. mining, agriculture, tourism). Impairment of an industry and / or damage to an asset that requires State Government financial assistance resulting in medium term (12 months or more). The recovery from loss of essential infrastructure is simple but requires financial assistance beyond the allocated budget.
Minor	Several injuries requiring treatment at the scene (e.g. minor injuries and abrasions, requiring less urgent medical attention).	Short term decline of economic activity (less than one year) and / or government revenues from industries (e.g. mining, agriculture, tourism). Minor damage to an industry and / or damage to an asset that requires the reallocation of budget for recovery, resulting in short term disruption (less than one year). The recovery from the loss of essential infrastructure achievable in short term through budget reallocation.
Insignificant	No reported injuries to emergency services.	Short term disruption to economic activity and / or loss of assets within an industry or sector. Inconsequential business sector disruption due to emergency event. Recovery from loss of essential infrastructure achievable within current budget allocations.

[23] Descriptors based on the Australian College for Emergency Medicine (ACEM) – Guidelines on the implementation of the Australasian Triage Scale in Emergency Departments, November 2013.

[24] In assessing the level of consequence for the loss of an ecosystem or species (i.e. catastrophic level of consequence for a region), a lower level of consequence would be allocated than at the state and national level if the species exists in other areas.

[25] In using the term 'Ecosystem' this includes the plants, animals and other species of that ecosystem, as well as the air, water and soil upon which those species depend.

[26] The term 'Environmental value' refers to environmental goods and services, including aesthetic and recreational facilities and resources.
Source: adapted from NERAG (Australian Institute for Disaster Resilience, 2015).

Community & Social	Public Administration	Environmental[24]
The community's social connectedness is irreparably broken, such that the community ceases to function effectively, breaks down and disperses in its entirety. This can be characterised by widespread loss of objects of cultural significance and impacts beyond emotional and psychological capacity across all parts of the community.	Sustained and frequent media criticism on national and international media outlets. Total loss of confidence from the general public. Governing bodies are unable to deliver core objectives, with disordered public administration. Interstate and international emergency services are required to assist in the restoration of basic services and public order and respond to calls for service.	Permanent destruction of an ecosystem or species[25] recognised at the Local, regional, State or national level and / or severe damage to or loss of an ecosystem or species recognised at the State and national level and / or significant loss or impairment of an ecosystem or species recognised at the national level. Permanent destruction of environmental values of interest[26].
The community's social connectedness is significantly broken, such that extraordinary external resources are required to return the community to functioning effectively, with significant permanent dispersal. This can be characterised by reduced quality of life within the community, significant loss of or damage to most objects of cultural significance, and impacts beyond emotional and psychological capacity in large parts of the community.	Sustained and frequent media criticism on national media outlets with infrequent media criticism on international media outlets. Loss of public confidence in governance. Governing bodies encounter severe reduction to core objectives with disordered public administration. Specialist emergency service areas required to assist front line officers in restoring basic services and public order and respond to calls for service.	Minor damage to ecosystems or species recognised at the national level and / or significant loss or impairment of an ecosystem or species recognised at the State level and / or severe damage to or loss of an ecosystem or species recognised at the Local or regional level. Severe damage to environmental values of interest.
The community's social connectedness is broken, such that community requires significant external resources to return the community to functioning effectively, with some permanent dispersal. This can be characterised by permanent damage to some objects of cultural significance and impacts beyond cultural and emotional capacity in some parts of the community.	Short term local critical media coverage. Some sections of the community are critical. Governing bodies encounter significant reduction to core objectives. Emergency services rosters of operations are stretched to manage the event.	Minor damage to ecosystems and species recognised at the State level and / or significant loss or impairment of an ecosystem or species recognised at the Local or regional level. Significant damage to environmental values of interest.
The community's social connectedness is damaged, such that community requires some external resources to return the community to functioning effectively, with no permanent dispersal. This can be characterised by repairable damage to objects of cultural significance and impacts within emotional and psychological capacity of the community.	Infrequent local critical media coverage. Isolated incidents of the public being critical. Governing bodies encounter limited reduction in delivery of core functions. Emergency services manage the event but with some extended hours of operations.	Minor damage to ecosystems and species recognised at the Local or regional level. Minor damage to environmental values of interest.
The community's social connectedness is disrupted, such that the reprioritisation and / or reallocation of existing resources is required to return the community to functioning effectively, with no permanent dispersal. There is no or minor damage to objects of cultural significance, and no adverse emotional and psychological impacts.	No local critical media coverage. No incidents of the public being critical. Governing bodies' delivery of core functions is unaffected or within normal parameters.	No damage to ecosystems at any level. Inconsequential damage to environmental values of interest.

Appendix 4 Risk matrix [27]

Likelihood (X)		Rare (1)					Unlikely (2)					Possible (3)					Likely (4)					Almost Certain (5)				
Vulnerability (Y)		V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)	V.Low (1)	Low (2)	Mod (3)	High (4)	Extr (5)
Consequence (Z)	INSIGNIFICANT (1)	VL1	VL2	VL3	L4	L5	VL2	VL3	L4	L5	L6	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9
	MINOR (2)	VL2	VL3	L4	L5	L6	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10
	MODERATE (3)	VL3	L4	L5	L6	M7	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11
	MAJOR (4)	L4	L5	L6	M7	M8	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11	M8	H9	H10	H11	E12
	CATASTROPHIC (5)	L5	L6	M7	M8	H9	L6	M7	M8	H9	H10	M7	M8	H9	H10	H11	M8	H9	H10	H11	E12	H9	H10	H11	E12	E13

Key: V.L= Very low; L = Low; M = Medium; H = High; E = Extreme

Scale: 1 (lowest) to 13 (highest)

Table 3 - Risk Matrix

[27] Overall risk level is calculated through the equation (X+Y+Z) – 2. Each of the qualitative input parameters (X, Y & Z) have been assigned a numerical value of 1-5 (where 1 is the lowest and 5 the highest) in order to output the overall level of risk severity. Risk severity is ranked from 1-13 (where 1 is the least severe and 13 the most). Furthermore, the severity scale has been bracketed along the following lines: Very Low Severity 1-3; Low Severity 4- 6; Medium Severity 7-8; High Severity 9-11; Extreme Severity 12-13.

Appendix 5: Example Risk Assessment Table

FOLD

% AEP – Derived from Process 1, Step 1. The assessment of the hazard against the probability of occurrence.

Exposed Elements – The summary of the findings of Process 1, Step 2 (geospatial analysis). A detailed list of the "elements at risk".

Vulnerability Rating – The decision from Process 1, Step 3. Assessment of the vulnerability of the exposed elements rated from "Very low" to "Extreme".

Hazard – The hazard under assessment including the category where appropriate.

Likelihood Rating – The decision from Process 2, Step 1. The assessment of likelihood of occurrence based on scenario modelling from the past 50 years of historical data.

Note: The Risk Assessment Table seeks to capture and visually articulate the outputs of each step of the risk assessment process.

A complete risk assessment table is comprised of the following **Exposed Elements** sections:

- Essential Infrastructure
- Access & Resupply
- Community & Social
- Medical
- Significant Industries
- Environmental.

Risk Assessment Table - (Kangerooville DDMG)
Tropical Cyclone (Most Likely Scenario - Category 2 Cyclone incorporating Moderate Riverine Flooding)

"Hazard (43% AEP)"		Exposed Elements[28]	Vulnerability	Likelihood	
TROPICAL CYCLONE - CATEGORY 2	Essential Infrastructure	**Power:** - **Bothwell Power Plant** (coal fired State asset) - Supplies 60% of power to State and is dependant on rail networks for supply. - **HV Line (132Kv)** through to Central Plains LGA is a single feed (Mulgowie to Coolgardie) and is vulnerable to sustained high winds. - **Powerlink lines** - vulnerability along the following sections: - Mulgowie to Dinoga - Mt Joey to Ennuin - Coolgardie to Mandurah - Rum Rum to Bothwell (Kangerooville). - **Sub-distribution network** is vulnerable to sustained high winds and flash flooding but majority of network can be bypassed or supported by generators (for essential civic infrastructure) if required.	High	Likely	**Agency/organisation** - Engage stakeholde mitigation strategies - Asset owners main community/DDMG. **Facility operators en** - Identify short term capacity for affected **Agency Business Co** - Establish long term **Established support** - Presence of asset - Community engage
		Communications: - **NbN** - NbN totally reliant on power. Location of NbN nodes at below 1% AEP flood height will result in inundation of a number of nodes resulting in District wide outages. - **Mobile Communications** - District wide and prolonged telecommunication outages due to reliance on power. Prolonged power outages leads to inability to charge mobile communication devices which will compound the issue. - Mobile communication towers situated within topographically exposed areas are vulnerable to high & sustained winds. - **Telstra Exchanges** - Majority have excellent redundancy in terms of power and are situated above a 1% AEP flood height but telephone exchange at Kangerooville is vulnerable to flash and riverine flooding.	High		**Agency/organisation** - Engage stakeholde mitigation strategies - Asset owners main community/DDMG. **Facility operators en** - Identify short term capacity for affected **Agency Business Co** - Establish long term **Established support** - Presence of asset - Community engage
		Water: - **Water treatment plants** are at risk due to reliance on power networks. Locations: - Mulgowie - Mandurah - Kangerooville - Dinoga - Bothwell - Coolgardie - Ennuin - Increased turbidity (District wide) will impact upon water quality (across a prolonged period and decreasing quality over the long term). - **Waste Water/Sewerage** - Loss of power to telemetry may affect treatment. - **Environmental** - Contamination through water debris. Alternative intake point upstream allows for control of contamination issues. - Hazard waste dams and abandoned mines are areas of concern (i.e. Mount Dinoga) resulting in heavy metal leaching, decreased Ph levels etc.	Moderate		**Facility operators en** - Identify short term capacity for affected - Asset owners main community/DDMG. **Agency Business Co** - Establish long term **Established support** - Presence of asset **Requisite governme** - DACC support **Resupply Guidelines** - DDMG have establ
		Transport Infrastructure: - **Airports** - Kangerooville airport will cease operations. Riverine flooding and infrastructure damage to terminal building could lead to downgrade of airport for 6-9 months. Infrastructure currently rated to Cyclone standard but some disruption to infrastructure could be expected. - Coolgardie Airport and Ennuin Airport - may suffer some infrastructure damage leading to disruption. - **Heliports** - Kangerooville Airport, Hospital based heliports. Alternative sites already mapped to prevent long term disruption. - **Bus and Rail Terminals** - Power supply to the terminals is the primary issue. Services will cease at 100kph wind speeds. - Ports - Kangerooville Industrial Port infrastructure highly resilient. Commercial businesses may be impacted. Evacuation of the port likely to occur. - Debris load within water may hamper restoration of service. - **Harbours** - Ennuin harbour (fisheries, policing, marine rescue, coast guard, tourism) may experience disruption. - Expect infrastructure damage to jetties, pontoons etc.	Low		**Community awarene** - Community engage - Communications pl **Agency/organisation** - Engage stakeholde mitigation strategies - Asset owners main community/DDMG. **Facility operators en** - Identify short term capacity for affected **Agency Business Co** - Establish long term
		Fuel Infrastructure: - **Bulk Fuel Storage** - Kangerooville Industrial Port fuel depot. - **Gas & Oil Pipelines** - Gas line from Coolgardie to Mandurah may be affected leading to economic disruption and disruption to domestic supply.	Low		**Agency/organisation** - Engage stakeholde redundancy or mitiga **Facility operators en** - Operators maintain **Agency Business Co** - Establish long term

[28] Geospatial tools and modelling should be utilised and referenced to justify inclusion of vulnerable exposed elements within the Risk Assessment Table.

FOLD

Existing Risk Treatments or Controls	Consequence	Risk Level	Risk Statements
emergency action/response plans. rs (i.e. asset owner/operator) to identify the level of redundancy or for specific assets in exposed areas. tain priority reconnection schedule developed in consultation with the ergency plans and business continuity plans. contingencies (i.e. back-up assets) for exposed assets that will provide civic infrastructure and communities. ontinuity Plans. plans for the mitigation of potential exposed sites. networks owner in DDCC and LDCC. - Communications Plan aimed at community. ement by asset owner.	Moderate	H9	Exposure, leading to damage to essential infrastructure (such as power stations, transmission lines, communication nodes and towers) resulting from sustained high winds, associated possible riverine flooding and minor coastal inundation will affect communities across Kangerooville in the event of the manifestation of a Tropical Cyclone (Category 2). Some redundant power generation is in place across key civic infrastructure and communities; although this is highly vulnerable to riverine flooding, coastal inundation and possible lack of resupply of fuel. Potential damage to infrastructure may close ports and airports in the short term subsequently affecting significant industries within the District. Significant disruption to communities and services without redundant power or communications through the short term (up to 1 week) is likely. Possible subsequent riverine flooding may further compound disruption issues (see Riverine Flooding Assessment).
emergency action/response plans. rs (i.e. asset owner/operator) to identify the level of redundancy or for specific assets in exposed areas. tain priority reconnection schedule developed in consultation with the ergency plans and business continuity plans. contingencies (i.e. back-up assets) for exposed assets that will provide civic infrastructure and communities. ontinuity Plans. plans for the mitigation of potential exposed sites. networks owner in DDCC and LDCC. - Communications Plan aimed at community. ement by asset owner.	Moderate	H9	
ergency plans and business continuity plans. contingencies (i.e. back-up assets) for exposed assets that will provide civic infrastructure and communities. tain priority reconnection schedule developed in consultation with the ontinuity Plans. plans for the mitigation of potential exposed sites. networks owner in DDCC and LDCC. t agencies ished arrangements to resupply sections of the community.	Moderate	M8	
ss and key messaging plans. ement by asset owner. lan aimed at community. emergency action/response plans. rs (i.e. asset owner/operator) to identify the level of redundancy or for specific assets in exposed areas. tain priority reconnection schedule developed in consultation with the ergency plans and business continuity plans. contingencies (i.e. back-up assets) for exposed assets that will provide civic infrastructure and communities. ontinuity Plans. plans for the mitigation of potential exposed sites.	Minor	L6	
emergency action/response plans. rs (i.e. asset owner/operator) to identify the level of ation strategies for specific assets in exposed areas. ergency plans and business continuity plans. lists for priority of supply during and post an event. ontinuity Plans. plans for the mitigation of potential exposed sites.	Minor	L6	

Existing Risk Treatment or Controls – An assessment of the current strategies, plans and resources that are in place and/or act to control or mitigate (treat) the identified vulnerabilities of exposed elements.

Consequence Rating – The decision from Process 2, Step 3. The assessment of the projected or anticipated impact of the hazard manifesting against the exposed elements after all existing treatments and controls have been considered. Rated from "Insignificant" to "Catastrophic".

Risk Statement – A concise summary of the full assessment of the hazard and the exposure, vulnerability and consequence of the elements found to be at risk. Risk statements provide further context for developing future risk treatments by concisely detailing the cause of the risk and its anticipated effects (consequences).

Inherent Risk Rating – the output of the two processes derived from the risk matrix. This assigns an overall severity rating across five levels of risk which range from "Very low" to "Extreme". Awarding an overall level of risk aids in the determination of risk priorities.

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Appendix 6: Sample Risk Register (Infrastructure)

Exposed Elements – Imported directly from the Risk Assessment Table.

Risk Statement – Imported directly from the Risk Assessment Table.

Inherent Risk Level – Imported directly from the Risk Assessment Table.

Register ID – An alphanumeric identification number which identifies the current version of the register (reviewed annually) and the priority of the specific hazard. (The number before the decimal point indicates the priority of the hazard for the District and the number after is the version of the Risk Register. In this example, 1.0 shows Tropical Cyclone is the highest priority hazard for this District and this is the first version of the Risk Register. Next year when the Risk Register is updated, and if Tropical Cyclone remained the number one priority, the numbering would shift to 1.1 to indicate the reviewed version of the register.)

Decision Log Reference Number – An alphanumeric identification number which is used to clearly link the relevant line of this Risk Register to the agreed actions in the Decision Log.

Note: The Risk Register summarises the outputs of the Risk Assessment Table to inform decision making on managing the identified risks.

A register should be completed for each of the **Exposed Elements** sections from the Risk Assessment Table:

- Essential Infrastructure
- Access & Resupply
- Community & Social
- Medical
- Significant Industries
- Environmental.

Risk Register - Kangerooville DDMG
Tropical Cyclone (Most Likely Scenario - Category 2 Cyclone incorporating Moderate Riverine Flooding)

ID	Decision Log Reference	Hazard	Exposed Elements (Infrastructure)	Risk State
	1.1		**Power:** - **Bothwell Power Plant** (coal fired State asset) - Supplies 60% of power to State and is dependant on rail networks for supply. - **HV Line (132Kv)** through to Central Plains LGA is a single feed (Mulgowie to Coolgardie) and is vulnerable to sustained high winds. - **Powerlink lines** - vulnerability along the following sections: - Mulgowie to Dinoga - Coolgardie to Mandurah - Mt Joey to Ennuin - Rum Rum to Bothwell (Kangerooville). - **Sub-distribution network** is vulnerable to sustained high winds and flash flooding but majority of network can be bypassed or supported by generators (for essential civic infrastructure) if required.	
	1.2		**Communications:** - **NbN** - NbN totally reliant on power. Location of NbN nodes at below 1% AEP flood height will result in inundation of a number of nodes resulting in District wide outages. - **Mobile Communications** - District wide and prolonged telecommunication outages due to reliance on power. Prolonged power outages leads to inability to charge mobile communication devices which will compound the issue. - Mobile communication towers situated within topographically exposed areas are vulnerable to high & sustained winds. - **Telstra Exchanges** - Majority have excellent redundancy in terms of power and are situated above a 1% AEP flood height but telephone exchange at Kangerooville is vulnerable to flash and riverine flooding.	
1.0	1.3	TROPICAL CYCLONE - CATEGORY 2	**Water:** - **Water treatment plants** are at risk due to reliance on power networks. Locations: - Mulgowie - Mandurah - Kangerooville - Dinoga - Bothwell - Coolgardie - Ennuin - Increased turbidity (District wide) will impact upon water quality (across a prolonged period and decreasing quality over the long term). - **Waste Water/Sewerage** - Loss of power to telemetry may affect treatment. - **Environmental** - Contamination through water debris. Alternative intake point upstream allows for control of contamination issues. - Hazard waste dams and abandoned mines are areas of concern (i.e. Mount Dinoga) resulting in heavy metal leaching, decreased Ph levels etc.	Exposure, leading essential infras as power station lines, communica towers) resulting high winds, asso riverine flooding a inundation will aff across Kangeroo of the manifestati Cyclone (Ca Some redundant po in place acro infrastructure an although this is h to riverine floo inundation and p resupply Potential damage may close ports the short term affecting signific within the Significant disruptio and services wit power or commun the short term (is lik Possible subsequen may further comp issues (see Riv Assess
	1.4		**Transport Infrastructure:** - **Airports** - Kangerooville airport will cease operations. Riverine flooding and infrastructure damage to terminal building could lead to downgrade of airport for 6-9 months. Infrastructure currently rated to Cyclone standard but some disruption to infrastructure could be expected. - Coolgardie Airport and Ennuin Airport - may suffer some infrastructure damage leading to disruption. - **Heliports** - Kangerooville Airport, Hospital based heliports. Alternative sites already mapped to prevent long term disruption. - **Bus and Rail Terminals** - Power supply to the terminals is the primary issue. Services will cease at 100kph wind speeds. - Ports - Kangerooville Industrial Port infrastructure highly resilient. Commercial businesses may be impacted. Evacuation of the port likely to occur. - Debris load within water may hamper restoration of service. - **Harbours** - Ennuin harbour (fisheries, policing, marine rescue, coast guard, tourism) may experience disruption. - Expect infrastructure damage to jetties, pontoons etc.	
	1.5		**Fuel Infrastructure:** - **Bulk Fuel Storage** - Kangerooville Industrial Port fuel depot. - **Gas & Oil Pipelines** - Gas line from Coolgardie to Mandurah may be affected leading to economic disruption and disruption to domestic supply.	

...ments	Inherent Risk	Existing Risk Treatments or Controls	Capability	Capacity
	H9	**Agency/organisation emergency action/response plans.** - Engage stakeholders (i.e. asset owner/operator) to identify the level of redundancy or mitigation strategies for specific assets in exposed areas. - Asset owners maintain priority reconnection schedule developed in consultation with the community/DDMG. **Facility operators emergency plans and business continuity plans.** - Identify short term contingencies (i.e. back-up assets) for exposed assets that will provide capacity for affected civic infrastructure and communities. **Agency Business Continuity Plans.** - Establish long term plans for the mitigation of potential exposed sites. **Established support networks** - Presence of asset owner in DDCC and LDCC. - Communications Plan aimed at community. - Community engagement by asset owner.	Asset owners have capability and expertise to maintain and restore services through BCPs. Asset owners have the capability to source, transport and resupply limited short term redundant generation capability to support key civic infrastructure. Presence of Energy Queensland representative in DDCC and LDCC to provide timely SITREPS. Asset owners to maintain priority reconnection schedule developed in consultation with the community.	Asset owners may require State support to restore services in the event of District/State wide outages. Convergence of support services may have logistical implications such as accommodation/meals which may impact local communities. The sub distribution network is highly vulnerable and Energy Queensland would likely require assistance to support restoration of services.
g to damage to tructure (such s, transmission ation nodes and from sustained ciated possible nd minor coastal ect communities ville in the event on of a Tropical ategory 2). wer generation is ss key civic d communities; ighly vulnerable ding, coastal ossible lack of of fuel. o infrastructure and airports in subsequently cant industries District. n to communities hout redundant ications through up to 1 week) ely. t riverine flooding ound disruption erine Flooding ment).	H9	**Agency/organisation emergency action/response plans.** - Engage stakeholders (i.e. asset owner/operator) to identify the level of redundancy or mitigation strategies for specific assets in exposed areas. - Asset owners maintain priority reconnection schedule developed in consultation with the community/DDMG. **Facility operators emergency plans and business continuity plans.** - Identify short term contingencies (i.e. back-up assets) for exposed assets that will provide capacity for affected civic infrastructure and communities. **Agency Business Continuity Plans.** - Establish long term plans for the mitigation of potential exposed sites. **Established support networks** - Presence of asset owner in DDCC and LDCC. - Communications Plan aimed at community. - Community engagement by asset owner.	Asset owners have capability and expertise to maintain and restore services through BCPs. Asset owners have the capability to source, transport and resupply redundant generation capability to restore power to exchanges and communication nodes. Presence of asset owner representative in DDCC and LDCC to provide timely SITREPS.	Asset owners may require State support to restore services in the event of District/State wide outages (especially in regard to the NbN network). Convergence of support services may have logistical implications such as accommodation/meals which may impact local communities.
	M8	**Facility operators emergency plans and business continuity plans.** - Identify short term contingencies (i.e. back-up assets) for exposed assets that will provide capacity for affected civic infrastructure and communities. - Asset owners maintain priority reconnection schedule developed in consultation with the community/DDMG. **Agency Business Continuity Plans.** - Establish long term plans for the mitigation of potential exposed sites. **Established support networks** - Presence of asset owner in DDCC and LDCC. **Requisite government agencies** - DACC support **Resupply Guidelines** - DDMG have established arrangements to resupply sections of the community.	Facility owners have capability and expertise to maintain and restore services through BCPs. Facility owners have the capability to source, transport and resupply redundant water supply (bowser and bulk bottled water) to manage contamination issues and any disruption to supply of clean water. Presence of asset owner representative in DDCC and LDCC to provide timely SITREPS.	Facility owners may require intra-State support for resupply of bulk clean water in the event of prolonged disruption. Priority for restoration of power supply should limit impact to asset/facility owners and therefore reduce the need to source bulk clean water.
	L6	**Community awareness and key messaging plans.** - Community engagement by asset owner. - Communications plan aimed at community. **Agency/organisation emergency action/response plans.** - Engage stakeholders (i.e. asset owner/operator) to identify the level of redundancy or mitigation strategies for specific assets in exposed areas. - Asset owners maintain priority reconnection schedule developed in consultation with the community/DDMG. **Facility operators emergency plans and business continuity plans.** - Identify short term contingencies (i.e. back-up assets) for exposed assets that will provide capacity for affected civic infrastructure and communities. **Agency Business Continuity Plans.** - Establish long term plans for the mitigation of potential exposed sites.	Facility owners have capability and expertise to restore services through BCPs. Facility owners have the capability to source, transport and resupply limited short term redundant power generation capability. This is in order to restore services within the shortest time possible. Operators have the capability to inform and update public, DDCC/LDCC and DTMR on the disruption to/restoration of services at the State and District level.	Restoration of key transport services to be expected within a few days. Supply of redundant power dependant on the assumption that disruption will be short term. <1 week. Ability to inform public, DDCC/LDCC and DTMR dependant on the availability of communication networks. Assumption within BCP for a 25-50% reduction in staffing levels and therefore vehicle/airframe numbers.
	L6	**Agency/organisation emergency action/response plans.** - Engage stakeholders (i.e. asset owner/operator) to identify the level of redundancy or mitigation strategies for specific assets in exposed areas. **Facility operators emergency plans and business continuity plans.** - Operators maintain lists for priority of supply during and post an event. **Agency Business Continuity Plans.** - Establish long term plans for the mitigation of potential exposed sites.	Facility owners have capability and expertise to restore services through BCPs. Operators BCPs highlight priority of resupply for fuel during and post event (Emergency Services etc.)	Bulk fuel storage maintained at 50% capacity prior to event. This equates to provision of 4 days supply to District priority list.

Capacity Gaps	Consequence	Residual Risk Rating	Accept Mitigate Transfer
Transportation and storage of heavy generation capability (medium term capability) and bulk fuel outside of BCPs. Logistical implications of convergence of support services outside current BCPs and DDMP. Lack of current cohesive plan between DTMR and Energy Queensland with regard to access/ resupply to key infrastructure sites.	**Moderate**	**M7**	**Mitigate & Transfer**
LDMGs, DDMGs and Agency Representatives reliant on Voice Over Internet Protocol (VoIP) to communicate with State agencies if mobile communications fail. No redundancy if NbN network is compromised. Lack of current cohesive plan between DTMR and asset owners (Telstra, NbN etc.) with regard to access/resupply to key network nodes/infrastructure.	**Moderate**	**M7**	**Mitigate & Transfer**
Widespread contamination issues (from industrial pollution) or increases in turbidity beyond tolerable levels outside of BCP and would require significant State support.	**Major**	**M7**	**Transfer**
Lack of representation to DDCC and LDCC to provide timely SITREPS. Transport operators highly susceptible to shortages of staff beyond BCP. Infrastructure damage beyond BCPs capability to manage (therefore requiring State support) and continuing access/resupply issues will compound disruption of services. No current communication strategy between DTMR rep on DDMG and District transport operators.	**Moderate**	**L4**	**Accept**
District reliance on single bulk fuel storage a concern at the DDMG level. Damage to storage facility or continuing resupply disruption may have significant impact across multiple response areas.	**Major**	**L5**	**Transfer**

Existing Risk Treatment or Controls – Imported directly from the Risk Assessment Table.

Capability – An assessment of the resources, plans and attributes within the Local or District Disaster Management Group (including stakeholders) which are able to manage, reduce or mitigate risks.

Capacity – An assessment of the ability of the Local or District Disaster Management Group (including stakeholders) to sustain their capability during an event.

Capacity Gaps – An assessment of the Local or District Disaster Management Group's gap in capability and/or capacity to manage the identified risk. Otherwise known as residual risk (or the risk that remains in unmanaged form.)

Consequence Rating – An assessment of the projected or anticipated impact of the gap in capability and/or capacity if they were to eventuate during the response to an event. This assessment will auto-generate the residual risk rating.

Residual Risk Rating – the magnitude of the residual risk expressed in terms of the combination of the inherent risk rating, assessment of existing treatment/ control measures and the consequences of the capacity gaps manifesting during an event.

Residual Risk Decision – The annotation of whether the residual risk will be accepted (tolerated), plans will be developed to mitigate the risk or it will be transferred (upon consultation) to the next level of the QDMA. This is recorded within the Decision Log.

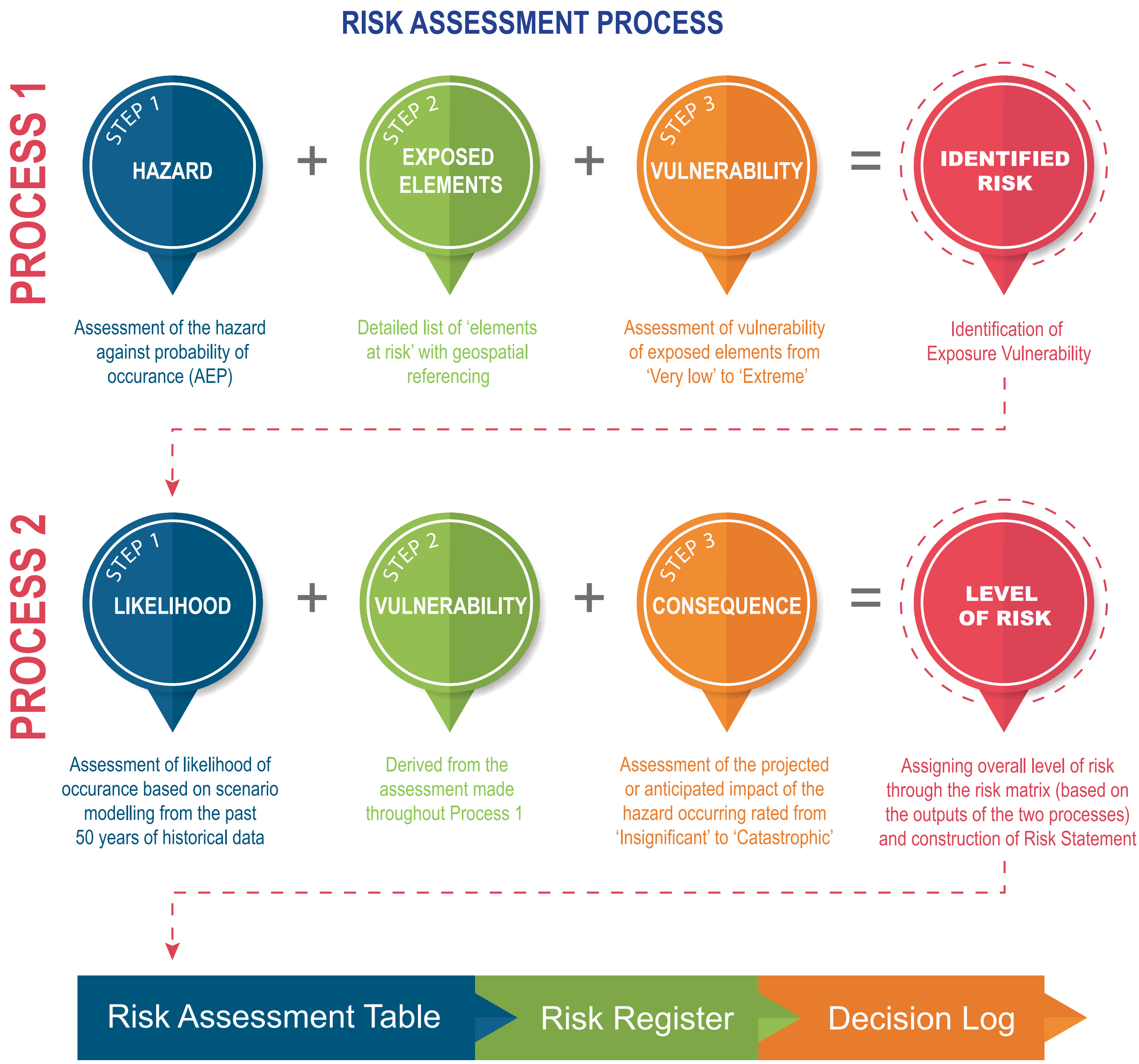
Appendix 7 Decision Log

The Decision Log is designed to outline and record 'key decisions' in the assessment of risks, including the rationale behind judgements and who has been involved in these decisions. In instances where the risk is transferrred from the Local level to the District, the rationale needs to be clearly outlined and justifiable.

Current Level of Responsibility	*Local, District, or State*
Decision Log Reference	*A numerical identifier that can be linked to the risk register for key decisions*

Risk ID No.	Decision	Decision Rationale	Decision Maker	Agreed By	Timeline	Status
Identifier for the risk from a risk register (i.e. transferral).	*Outline of the issue and what was the specific decision surrounding this issue.*	*The decision rationale is the justification for the decision.* *e.g. "Options A, B, C were considered & A was the preferred option because … "*	*The decision maker is the person or group of persons who reached the final decision.*	*While the decision maker proposes and has the authority to make decisions, there are instances when groups of individuals must support the decision so that it can be implemented. Please identify the remainder of the parties that agreed to the decision in this column.*	*Please outline the agreed timeline (if applicable) for the implementation of the decision. This should include details of the responsible parties for monitoring the progress of implementation.*	*Select a category (i.e. Decided, Accepted, Rejected, In progress).*

Appendix 8 Risk assessment process on a page



Glossary

All-hazards approach

Dealing with all types of emergencies or disasters, and civil defence, using the same set of management arrangements. (Australian Emergency Management Institute, 2015)

Anthropogenic hazards

Human-induced hazards which are induced entirely or predominantly by human activities and choices. (United Nations Office for Disaster Risk Reduction, 2017)

Capability

The combination of all the strengths, attributes and resources available within an organisation, community or society to manage and reduce risks and strengthen resilience. Capability may include infrastructure, institutions, human knowledge and skills, and collective attributes such as social relationships, leadership and management. (United Nations Office for Disaster Risk Reduction, 2017)

Capacity

A subset of capability, referring to the ability to sustain that effect for a designated period. (Adapted from Australian Defence Force, 2012)

Community preparedness

The degree of plans in place by communities, households and individuals that, when implemented, can reduce the adverse effects of emergency events. (Australian Emergency Management Institute, 2015)

Consequence

The outcome or impact of an event and may be expressed qualitatively or quantitatively. There can be more than one consequence from an event. Consequences are generally described as the effects on people, society, the environment and the economy. (Geoscience Australia)

Critical infrastructure

The physical structures, facilities, networks and other assets that support services that are socially, economically or operationally essential to the functioning of a society or community. (United Nations Office for Disaster Risk Reduction, 2017)

Disaster

A serious disruption in a community, caused by the impact of an event that requires a significant coordinated response by the State and other entities to help the community to recover from the disruption. (Disaster Management Act 2003)

Emergency

An event, actual or imminent, that endangers or threatens to endanger life, property or the environment, and requires a significant and coordinated response. In some jurisdictions emergency is interchangeable with disaster. (Australian Emergency Management Institute, 2015)

Establishing the context

Defining the external and internal parameters to be taken into account when managing risk, and setting the scope and risk criteria for the risk management activity. (Australian Emergency Management Institute, 2015)

Event

An event may be natural or caused by human acts or omissions. (Disaster Management Act 2003)
It can include any of the following:

(a) A cyclone, earthquake, flood, storm, storm tide, tornado, tsunami, volcanic eruption or other natural occurrence;

(b) An explosion or fire, a chemical, fuel or oil spill, or a gas leak;

(c) An infestation, plague or epidemic;

(d) A failure of, or disruption to, an essential service or infrastructure;

(e) An attack against the State;

(f) Another event similar to an event mentioned in paragraphs (a) to (e).

Exposure

The elements within a given area that have been, or could be, subject to the impact of a particular hazard. Exposure is also sometimes referred to as the 'elements at risk'. (Australian Emergency Management Institute, 2015)

Geospatial

Relating to or denoting data that is associated with a particular location or that has a geographic component to it. These components can be in the form of coordinates, addresses or postcodes. (Australian Geospatial-Intelligence Organisation)

Hazard

A process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation. (United Nations Office for Disaster Risk Reduction, 2017)

Level of risk (or risk level)

Magnitude of a risk, or a combination of risks, expressed in terms of the combination of vulnerability, consequence and their likelihood. (Australian Emergency Management Institute, 2015)

Likelihood

The chance of something happening whether defined, measured or determined objectively or subjectively, qualitatively or quantitatively and described using general terms or mathematically. (Standards Australia/ Standards New Zealand Standard Committee, 2009)

Mitigation

Measures taken in advance of a disaster aimed at decreasing or eliminating its impact on society and the environment. (Australian Emergency Management Institute, 2015)

Monitoring

Continual checking, supervising, critically observing or determining the status to identify change from the performance level required or expected. Monitoring can be applied to a risk management framework, risk management process, risk or control. (Australian Emergency Management Institute, 2015)

Natural hazards

Those which are predominantly associated with natural processes and phenomena. (United Nations Office for Disaster Risk Reduction, 2017)

Network

A group or system of interconnected people or things. (Australian Emergency Management Institute, 2015)

Node

A point in a network at which lines or pathways intersect or branch. (Australian Emergency Management Institute, 2015)

Preparedness

Arrangements to ensure that, should an emergency occur, all the resources and services that are needed to cope with the effects can be efficiently mobilised and deployed. (Australian Emergency Management Institute, 2015)

Redundancy

Additional or alternative systems, sub-systems, assets, or processes that maintain a degree of overall functionality in case of loss or failure of another system, subsystem, asset, or process. (United Nations Office for Disaster Risk Reduction)

Residual risk

The risk that remains in unmanaged form, even when effective disaster risk reduction measures are in place, and for which emergency response and recovery capacities must be maintained. (United Nations Office for Disaster Risk Reduction, 2017)

Resilience

The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management. (United Nations Office for Disaster Risk Reduction, 2017)

Risk

The concept of risk combines an understanding of the likelihood of a hazardous event occurring with an assessment of its impact represented by interactions between hazards, elements at risk and vulnerability. (Geoscience Australia)

The effect of uncertainty on objectives. (Standards Australia/Standards New Zealand Standard Committee, 2009)

Risk assessment

An approach to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that together could potentially harm exposed people, property, services, livelihoods and the environment on which they depend. (United Nations Office for Disaster Risk Reduction, 2015)

Risk control

The implementation and enforcement of actions to control risk, and the periodic re-evaluation of the effectiveness of these actions. (Australian Emergency Management Institute, 2015)

Risk description

Structured statement of risk usually containing five elements: sources, events, causes, vulnerability and consequences. (Australian Emergency Management Institute, 2015)

Risk evaluation

The stage at which values and judgment enter the decision process, explicitly or implicitly, by including consideration of the importance of the estimated risks and the associated social, environmental and economic consequences, in order to identify a range of alternatives for managing the risks. (Australian Emergency Management Institute, 2015)

Risk identification

The process of finding, recognising and describing risks. Risk identification involves the identification of risk sources, events, their causes and their potential consequences. Risk identification can involve [the use of] historical data, theoretical analysis, informed and expert opinions and stakeholders' needs. (Australian Emergency Management Institute, 2015)

Risk management

The systematic application of management policies, procedures and practices to the tasks of identifying, analysing, assessing, mitigating and monitoring risk. (Australian Emergency Management Institute, 2015)

Risk management framework

A set of components that provide the foundations and organisational arrangements for designing, implementing, monitoring, reviewing and continually improving risk management throughout the organisation. (Australian Emergency Management Institute, 2015)

Risk Register

A table, list or other representation of risk statements describing sources of risk and elements at risk with assigned consequences, likelihoods and levels of risk. Risk registers are produced by risk assessment processes, summarising the outputs of these processes to inform decision making about risks. Risk registers record the identification, analysis and evaluation of emergency risks. (Australian Emergency Management Institute, 2015)

Risk source

An element which, alone or in combination, has the intrinsic potential to give rise to risk. A risk source can be tangible or intangible. (Australian Emergency Management Institute, 2015)

Risk tolerance

An organisation's (or jurisdiction's) or stakeholder's readiness to bear the risk, after risk treatment, to achieve its objectives. Risk tolerance can be influenced by legal or regulatory requirements. (Australian Emergency Management Institute, 2015)

Socionatural hazards

Those associated with a combination of natural and anthropogenic factors, including environmental degradation and climate change. (United Nations Office for Disaster Risk Reduction, 2017)

System

A set of things working together as parts of an interconnecting network; a complex whole. (Australian Emergency Management Institute, 2015)

Vulnerability

The characteristics and circumstances of a community, system or asset that make it susceptible to the damaging effects of a hazard. (United Nations Office for Disaster Risk Reduction)

Bibliography

Australian Defence Force. (2012). Defence Capability Development Handbook.

Australian Emergency Management Institute. (2015). *National Emergency Risk Assessment Guidelines*. Canberra: Australian Government Attorney-General's Department.

Deloitte & Touche. (October 2012). *Risk Assessment in Practice.* Committee of Sponsoring Organisations of the Treadway Commission.

Geoscience Australia. (2007). Natural Hazards in Australia: Identifying Risk Analysis Requirements.

Global Facility for Disaster Reduction and Recovery (GFDRR). (2015). Understanding Risk in an Evolving World. Emerging Best Practice in Natural Disaster Risk Assessment.

Inspector-General Emergency Management. (2014). *Emergency Management Assurance Framework*. Brisbane: State of Queensland.

Middlemann, M. H. (2007). Natural Hazards in Australia. Identifying Risk Analysis Requirements. Canberra: Geoscience Australia.

Productivity Commission. (2014). Natural Disaster Funding Arrangements, Inquiry Report no. 74, Vol 1 & 2. Canberra: Commonwealth of Australia.

Queensland Disaster Management Committee. (May 2015). *Queensland State Disaster Management Plan*.

Queensland Parliament. (October 2014). Disaster Management Act 2003. Queensland. Retrieved from https://www.legislation.qld.gov.au/leGIsltn/CUrrent/D/DisastmanA03.pdf

Queensland Treasury. (July 2011). *A Guide to Risk Management*. Brisbane: Queensland Government.

Risk Frontiers. (April 2011). State-wide Natural Hazard Risk Assessment. Report 2: Historical analysis of natural hazard building loses, fatalities and expenditure for Queensland. Brisbane: Department of Community Safety.

Risk Frontiers. (February 2013). A Review of Best Practice in Natural Disaster Risk Registers and Risk Assessment. Brisbane: Department of Community Safety.

Risk Frontiers. (February 2013). *Queensland Natural Disaster Risk Register Framework*. Brisbane: Queensland Department of Community Safety.

Risk Frontiers. (February 2013). *Queensland Natural Disaster Risk Register Guideline*. Brisbane: Department of Community Safety.

Risk Frontiers. (February 2013). *Queensland Natural Disaster Risk Register Tools*. Brisbane: Department of Community Safety.

Risk Frontiers. (February 2013). Review of Disaster Management Policies and Legislation Relevant to Risk Registers in Queensland. Brisbane: Department of Community Safety.

Risk Frontiers. (October 2012). Historical analysis of natural hazard building losses and fatalities for Queensland 1900-2011. Department of Community Safety.

Standards Australia/Standards New Zealand Standard Committee. (2006). *HB 167:2006 Security Risk Management*.

Standards Australia/Standards New Zealand Standard Committee. (November 2009). *AS/NZS ISO31000:2009, Risk Management-Principles and Guidelines*.

United Nations Office for Disaster Risk Reduction. (2015, August). *Background Paper Proposed Updated Terminology on Disaster Risk Reduction*. Retrieved September 14, 2015, from United Nations Office for Disaster Risk Reduction: http://www.preventionweb.net/files/45462_backgoundpaperonterminologyaugust20.pdf

United Nations Office for Disaster Risk Reduction. (2015). *Sendai Framework for Disaster Risk Reduction 2015-2030. United Nations.*

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